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PRINCIPLES

OF

PHARMACY

BY

HENRY V. ARNY, Ph. G., Ph. D., F. C. S.

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SECOND EDITION, REVISED
WITH 267 ILLUSTRATIONS

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PREFACE TO THE SECOND EDITION

The gratifying reception accorded the first edition of this book, coupled with the appearance of the ninth revision of the United States Pharmacopœia and of the fourth edition of the National Formulary has brought the need of a new edition. In preparing this a radical revision was rendered necessary by the strides made in pharmacy, medicine and chemistry during the past eight years.

The greatest difficulty encountered was the limitation of the work to its present size and in order to do this most of the recent information, including the data concerning the new Pharmacopœia and the Formulary, is presented in the most concise form consistent with clarity. This has been aided by inserting at the end of each chapter bibliographical references to which the student desiring more extended information can turn.

The thanks of the writer are extended Miss Adelaide Rudolph, M. A., for valuable services in the preparation of the bibliography, to Leo Roon, M. S., for assistance in revising Part I., and to Professor Jeannot Hostmann for aid in the revision of Part V; also to Dr. Hugo H. Schaefer and to George G. Schneider, A.B., for assistance in proof reading.

Lastly, mention must be made of the facilities offered by the libraries of the New York College of Pharmacy and of the Chemists' Club, without which the preparation of the bibliography would have been almost impossible.

H. V. ARNY.

NEW YORK CITY,
March, 1917.

PREFACE

THE subject of pharmacy as understood by the writer consists of the practical application of the sciences of physics and chemistry to medicines and their preparations, as well as sufficient botany to appreciate the character of those vegetable drugs entering into pharmaceutical preparations. As far as botany is concerned, the application of that science to medicine consists in that distinct study, materia medica, but of greater difficulty is an attempt to study the pharmacy of chemicals, both inorganic and organic, without at least some explanation of the principles underlying the science of chemistry. This explains the brief Introductory Chapters to Parts III and IV, which students have found of value as an adjunct to their instruction in pure chemistry.

While not desiring to hamper instruction by artificial limitations, the entire subject of pharmacy is so vast that some gleaning of essentials from those substances of minor importance appeals to the teacher as imperative, and we are fortunate in having a means of elimination in the use of our national standard, the United States Pharmacopœia. Of course no pharmaceutical instruction would prove sufficient were all unofficial drugs excluded, but the existence of a pharmacopœia makes it possible to use that work as the basis of instruction, and in drilling the student in official substances ample opportunity is afforded to refer to those unofficials suggested by the pharmacopœial preparation under consideration.

The book consists of seven parts:

- Part I deals with pharmaceutical processes and a striking feature is the discussion of the arithmetic of pharmacy.
- Part II deals with the galenical preparations of the pharmacopœia and those unofficials worthy of notice. It will be noticed that, wherever possible, these preparations are grouped around a typical pharmacopœial recipe, thus avoiding repetition.
- Part III deals with the inorganic chemicals used in pharmacy, has an introductory chapter on chemical theories, and discusses chemical arithmetic very fully.
- Part IV discusses the organic chemicals used in pharmacy, and that according to the most modern classification. Like Part III, it begins with an introductory chapter on the theory of the class of chemicals discussed.
- Part V is devoted to chemical testing, and summarizes the analytic methods of the Pharmacopœia.
- Part VI takes up the prescription from the time it is written to the time it is dispensed.
- Part VII gives the laboratory work which has been followed with much success by students of the writer. A notable feature of this part is the exercise in equation writing and in chemical arithmetic that the work affords.

H. V. ARNY.

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LIST OF ABBREVIATIONS

A. = *Annalen der Chemie und Pharmacie.*
A. J. P. = *American Journal of Pharmacy.*
A. Ph. A. = *Proceedings of the American Pharmaceutical Association.*
Am. Ch. Jl. = *American Chemical Journal.*
Am. Dr. = *American Druggist and Pharmaceutical Record.*
Am. Jl. Physiol. = *American Journal of Physiology.*
Analyst = *The Analyst.*
Ann. chim. phys. = *Annales de chimie et de physique.*
Ann. Phil. = *Annals of Philosophy.*
Arch. d. Pharm. = *Archiv der Pharmazie.*
B. = *Berichte der deutschen Chemischen Gesellschaft.*
Ber. d. Pharm. Ges. = *Berichte der deutschen Pharmazeutischen Gesellschaft.*
Bull. Assoc. chim. suc. dist. = *Bulletin de l'Association des chimistes de sucrerie et de distillerie.*
Bull. Pharm. = *Bulletin of Pharmacy.*
Bull. sci. pharmacol. = *Bulletin des sciences pharmacologiques.*
C. A. = *Chemical Abstracts.*
Ch. & Dr. = *The Chemist and Druggist.*
Ch. Cent. = *Chemisches Centralblatt.*
Ch. Eng. = *The Chemical Engineer.*
Ch. News = *The Chemical News.*
Ch. Zt. = *Chemiker-Zeitung.*
Ch. Zt. Rep. = *Chemisch-technisches Repertorium...Beilage zur Chemiker-Zeitung.*
Comp. rend. = *Comptes rendus des séances de l'Academie des sciences.*
D. A. Ap. Zt. = *Deutsch-amerikanische Apotheker-Zeitung.*
Dingl. = *Dingler's Polytechnisches Journal.*
Dr. Circ. = *The Druggists' Circular.*
8th Int. Cong. App. Ch. = *Proceedings of the Eighth International Congress of Applied Chemistry.*
Elect. World = *The Electrical World.*
Eng. Min. Jl. = *The Engineering and Mining Journal.*
F. I. D. = *Food Inspection Decision, Bureau of Chemistry, U. S. Department of Agriculture.*
Hager, Handb. = *Hager's Handbuch de Pharmaceubuchen Praxis*, 1913.
Int. Cong. App. Ch. = *Proceedings of the International Congress of Applied Chemistry.*
J. B. = *Jahresbericht über die Fortschritte der Chemie und verwandter Teile anderer Wissenschaften.*
Jl. A. M. A. = *The Journal of the American Medical Association.*
J. Am. Ch. Soc. = *The Journal of the American Chemical Society.*
Jl. A. Ph. A. = *The Journal of the American Pharmaceutical Association.*
Jl. Ch. Soc. = *The Journal of the Chemical Society.*
Jl. de ph. = *Journal de pharmacie.*
Jl. de ph. et ch. = *Journal de pharmacie et de chimie.*
Jl. Exp. Med. = *Journal of Experimental Medicine.*
Jl. Frank. Inst. = *Journal of the Franklin Institute.*
Jl. Ind. Eng. Ch. = *The Journal of Industrial and Engineering Chemistry.*
Jl. Phys. Ch. = *The Journal of Physical Chemistry.*
Jl. Physiol. = *Journal of Physiology.*
Jl. prakt. Ch. = *Journal für praktische Chemie.*
Jl. Soc. Ch. Ind. = *Journal of the Society of Chemical Industry.*
Merck's Rep. = *Merck's Report.*
Met. Ch. Eng. = *Metallurgical and Chemical Engineering.*
Meyer Bros. Drug. = *Meyer Brothers' Druggist*
N. J. Ph. A. = *Proceedings of the New Jersey Pharmaceutical Association.*
N. R. = *New Remedies.*
Nat. Dr. = *The National Druggist.*

Perf. Ess. Oil Rec. = *Perfumery and Essential Oil Record.*
Ph. Arch. = *Pharmaceutical Archives.*
Ph. Cent. = *Pharmaceutische Centralhalle.*
Ph. Jl. = *The Pharmaceutical Journal and Pharmacist.*
Ph. Post = *Pharmaceutische Post.*
Ph. Rec. = *The Pharmaceutical Record.*
Ph. Rev. = *Pharmaceutical Review.*
Ph. Rund. = *Pharmaceutische Rundschau.*
Ph. Zt. = *Pharmazeutische Zeitung.*
Pharm. Era = *The Pharmaceutical Era.*
Phil. Trans. = *Philosophical Transactions of the Royal Society of London.*
Pract. Dr. = *The Practical Druggist.*
Proc. Ch. Soc. = *Proceedings of the Chemical Society.*
Rep. Lab. A. M. A. = *Reports of the Chemical Laboratory of the American Medical Association.*
Repert. Pharm. = *Repertorium für die Pharmacie; von J. A. Buchner.*
Rev. chem. ind. = *Revue de chemie industrille.*
Rev. gén. sci. = *Revue générale des sciences pures et appliquées.*
Schimmel's Rep. = *Semi-annual Reports of Schimmel & Co.*
Sch. Wsch. Ch. Ph. = *Schweizerische Wochenschrift für Chemie und Pharmacie.*
Schweigger's Jl. = *Journal für Chemie und Physik; hrsg. von S. C. Schweigger.*
Tschirch = *Handbook der Pharmakognosie.*
Tschirch, Die Harze = *Die Harze und Harzbehälter by A. Tschirch,* 1 06.
West. Dr. = *The Western Druggist.*
Yearbook A. Ph. A. = *Yearbook of the American Pharmaceutical Association.*
Yearbook Pharm. = *Yearbook of Pharmacy; with the Transactions of the British Pharmaceutical Conference.*
Zt. analyt. Ch. = *Zeitschrift für analytische Chemie.*
Zt. angew. Ch. = *Zeitschrift für angewandte Chemie.*
Zt. anorg. Ch. = *Zeitschrift für anorganische Chemie.*
Zt. Biol. = *Zeitschrift für Biology.*
Zt. Chem. = *Zeitschrift für Chemie.*
Zt. Elektrochem. = *Zeitschrift für Elektrochemie und angewandte physikalische Chemie.*
Zt. physiol. Ch. = *Zeitschrift für physiologische Chemie (Hoppe-Seyler's).*

PRINCIPLES OF PHARMACY

PART I

PHARMACEUTIC OPERATIONS AND APPLIANCES

CHAPTER I

PHARMACOPŒIAS AND OTHER BOOKS ON PHARMACY

THE study of **pharmacy** means the study of the theories and exercise of the operations necessary to the intelligent preparing and dispensing of substances used in the healing art. The two Greek words designating this idea were *pharmacon*, "a drug, a medicine, remedy, a potion, charm, spell," and *apotheke*, "a repository; a storehouse." The first of these roots has been anglicized into such words as *pharmacy*, the art of preparing, preserving, compounding, and dispensing medicines, and *pharmacist*, one skilled in pharmacy; while from the second we get *apothecary*, one who practises pharmacy. Another word derived from the former root is pharmacopœia: *pharmacon*, "medicine," and *poiein*, "to make;" literally, "the making of medicines," but now used to designate a book of medical recipes prepared or approved by the government of the country where published. The history of pharmacopœias means the history of pharmacy, for as pharmacopœias evolved from crude handbooks of medical lore to the present works of high scientific value, even so has the practice of pharmacy progressed from the jumbling of crude and often disgusting ingredients, of which the manipulator knew but little, to the modern blending of carefully refined constituents, of which the operator knows not only the past history, but also the future action, both chemic and therapeutic.

The earliest works answering to a pharmacopœia are Egyptian papyri, such as Papyrus No. 37 of the Berlin Museum, which is a fragment from B.C. 1700, and from its historic references seems to be a copy of a manuscript of B.C. 4000. In it five forms of medicine—ointments, liniments, poultices, clysters, and potions—are mentioned. The famous Eber Papyrus, while of later date (B.C. 1552), is peculiarly valuable because of its completeness. In it mention is made of such drugs as calamus and myrrh, salt and sodium carbonate, while its list of preparations includes all given in Papyrus No. 37, among others, pills, mixtures, and decoctions.

Passing down to classic times, we find many medical works written by individuals which may be classed among the pharmacopœias, such as books of Hippocrates (B.C. 460–377), Dioscorides (either first or second century of the Christian era), and Galen (A.D. 131–201). These books were considered as standards by physicians for many centuries, scarcely being replaced until the appearance of the works of Paracelsus and of other medieval writers. Among the medieval works of medicine worthy of special note mention should be made of the "Ricettario," published by the College of Medicine of Florence (1498), and the "Pharmacorum Omnium" of Valerius Cordus (1546). The latter work, published by the city of Nuremburg after the death of the writer, began a series of municipal pharmacopœias, such as those of London (1618), Paris (1639), Edinburgh (1699), which answered the requirements of the age of municipal isolation, but as means of transportation improved and people traveled freely to and fro, it was found that the difference in pharmacopœias was productive of confusion; that, for instance, a traveler from Nuremburg having his prescription compounded in Frankfort was in danger of an excessive dose of a potent preparation, there being no uniformity in the preparations of the different municipal pharmacopœias. Accordingly, a demand for national pharmacopœias grew, and the first to appear was the Codex Medicamentarius, published by the French government in 1818, the successor of the Paris Pharmacopœia, with its authority extended through all of France.

The next national pharmacopœia was that of the United States, published in 1821. The merging of the pharmacopœias of London, Edinburgh, and Dublin into the British Pharmacopœia did not occur until 1864, while in Germany the municipal pharmacopœias were replaced first by those of the States of Germany (Prussia, Hanover, Saxony, etc.), and these merged into the national authority in 1872.

At the present time there are some twenty national pharmacopœias in force, including those of every country of Europe (save some of the Balkan States and Turkey), the United States, Argentine, Chili, Venezuela and Mexico representing Latin America, and Japan representing Asia. Canada and other colonies of England use the British Pharmacopœia.

Even as the municipal pharmacopœias of preceding centuries caused confusion as the means of communication improved, to-day, when it is easier to travel from New York to Berlin than it was to go from Munich to Berlin a hundred years since, we are confronted by the confusion of the several national pharmacopœias. Thus every year thousands of Americans travel abroad, taking with them the prescriptions of their American physicians, and if the prescription calls for a tincture, it is quite likely that the tincture dispensed in good faith by the French pharmacist may be of entirely different strength from the American preparation, because made according to the French Codex. A most startling example of this kind is afforded by that potent preparation, tincture of aconite root. Thus in the nineties, the United States Pharmacopœia directed that 100 mils represent the active strength of 35 Gm. of drug (35 per cent.); the tincture of the German Pharmacopœia was but 10 per cent.; the French Codex directed it to be 20 per cent.; while the strength of the British was 12 per cent. It is self-evident what dangerous results would have ensued if an American pharmacist had dispensed the tincture of the United States Pharmacopœia on a prescription written by a German physician; hence it is the duty of every druggist to acquaint himself with the strength of foreign preparations by reference to dispensatories.

This diversity of strength has called forth a demand for an *international pharmacopœia*, including at least preparations of all the potent drugs, so that one strength—say of tincture of aconite—be authorized by all the national pharmacopœias, and thus the same preparation be dispensed at all pharmacies in the world. This question was discussed at the first international pharmaceutic conference held in Brunswick in 1865, and has been brought up at every subsequent conference (Paris, 1867; Vienna, 1869; St. Petersburg, 1874; London, 1881; Brussels, 1885; Chicago, 1893; Brussels, 1897; Paris, 1900; Brussels, 1910; The Hague, 1913), but little progress in that direction has been accomplished. One of the first practical moves beyond the stereotyped resolutions and preliminary drafts was the action in 1893 of the American Pharmaceutical Association in donating $1000 to the international conference for defraying the expenses of compiling, publishing, and distributing such a work, and, lastly, in 1902 a conference of delegates appointed by the States of Europe and by the United States met in Brussels and decided upon a list of forty-three drugs and preparations which they recommended to the pharmacopœial commissions of all the countries of the world for adoption in the next edition of the pharmacopœia of each country.

Thus, among others, was the recommendation that tincture of aconite and tinctures of other potent remedies be placed at a uniform strength of 10 per cent. in all the pharmacopœias of the world. Another recommendation was that syrup of ferrous iodide be made so as to contain 5 per cent. of ferrous iodide.

Those official preparations conforming to the requirements of the Brussels Conference are designated in the present United States Pharmacopœia by a special synonym followed by the initials "P.I."—*præscriptio internationalis.*

The committee preparing the new pharmacopœia of the United States embodies in that standard most of the forty-three recommendations, and the same step is being taken by other national pharmacopœial commissions thus tending to make preparations of potent remedies the same strength the world over.

Turning to our own standard, the *Pharmacopœia of the United States*, this important work was inaugurated by Dr. Lyman Spaulding of New York, who in 1817 started the movement by suggesting that the country be divided into four districts, and all medical colleges and medical societies in each district be invited to send delegates to a district convention which should form an outline of a pharmacopœia. Each convention, in turn, should send delegates to a national convention which was, indeed, held at the capitol in Washington on January 1, 1820. At this convention two drafts of prospective pharmacopœias were submitted, and these were compared, consolidated, and revised in convention and ordered published, and in the following December there appeared the first pharmacopœia of the United States. The convention of 1820 arranged that a revision should occur in 1830, by ordering the four districts to elect and send three delegates each to a convention to be held in Washington on January 1, 1830. The method of election of these delegates resulted in a misunderstanding and the holding of two conventions and publishing of two pharmacopœias; the officers of the convention of 1820 holding a poorly attended meeting at New York. The discontents held a convention at Washington, at which the surgeon of the army and the senior surgeon of the navy were present, thus giving indirect governmental authority to the pharmacopœia so issued. Another important step was the intrusting of the publication of the revised pharmacopœia to a committee of revision of seventeen members rather than preparing a hurried work on the floor of the convention. This pharmacopœia appeared in 1831.

The convention of 1840 was arranged by the Washington convention of 1830 on lines followed to this day. Every incorporated medical society and medical college was invited to send three delegates to the convention, which met the first Monday in January.

Twenty delegates were present, and a committee of revision of seven members was elected. This committee was authorized to ask the coöperation of the pharmacy colleges in the work of revision, and, furthermore, the convention directed the presiding officer to invite the colleges of pharmacy to send delegates to the 1850 convention, which was called for the first Monday in May. The pharmacopœia was issued in 1842 and directed the process of percolation for the first time.

At the convention of 1850 pharmacists were present as delegates for the first time, and there were thirty delegates in all. A committee of four was elected to revise the pharmacopœia, and the fruit of their labor was published in 1851. The convention of 1860 was attended by thirty delegates, and a committee of revision of nine members published the pharmacopœia in 1863.

Sixty delegates were present at the convention of 1870; a revision committee of fifteen members was appointed and given general instruction as usual, and arrangements were made for the calling of the next convention.

At the convention of 1880, 109 delegates were present, representing thirty-five medical and eleven pharmaceutical bodies and the committee of revision chosen consisted of eleven physicians and fourteen pharmacists. To the convention of 1890, delegates from the various State pharmaceutical associations were invited, and accordingly fifty medical bodies and fifty-nine pharmaceutic organizations were represented; the committee on revision chosen consisting of ten physicians and sixteen pharmacists. Seated at the convention of 1900 were delegates from fifty-seven medical and fifty-nine pharmaceutic bodies and there was elected a revision committee consisting of six physicians and nineteen pharmacists.

The last convention was held in May, 1910. At this, in addition to delegates from government bureaus, from the American Dental Association, the American Chemical Society and from the national food chemists' associations there were represented seventy-seven medical and seventy-four pharmaceutical bodies; 140 medical and dental delegates and 171 pharmaceutical and chemical delegates being present. The committee of revision was enlarged to fifty members and the work was subdivided among fifteen sub-committees. The chairmen of each of these fifteen sub-committees were constituted an executive committee of revision, to which the intimate details of revision was entrusted. This committee of revision consists of twelve physicians and thirty-eight pharmacists and chemists. To a pharmacist the study of the history of his pharmacopœia should be a source of satisfaction and pride, as therein he will note the gradually increasing influence of the pharmacist in the framing of his national pharmacopœia. In 1820 the work was done by physicians only; in 1910 the pharmacists on the revision committee outnumbered the physicians three to one. Moreover, each pharmacist should appreciate that he can have direct voice in saying who can revise his pharmacopœia, as every reputable pharmacist is eligible to membership to his State pharmaceutical association, and at the meeting prior to the convention an election of delegates to the convention is held. As mentioned in the definition on p. 18, a modern pharmacopœia differs from other books on medicine by being either published by the government or by receiving governmental approval. In England and in Germany, for example, the pharmacopœia is prepared by commissions appointed by the government. In this country the national government has nothing to do with the publication of the pharmacopœia, except sending delegates from the medical, pharmaceutical and other scientific branches of the federal service. Of late years the pharmacopœia has attained semi-national importance, since not only is it used in government hospitals and dispensaries, but also is mentioned in the Food and Drug Laws of 1906 as the standard in testing official articles by governmental chemists. In the administration of similar food and drug acts of the several states, the pharmacopœia is likewise accepted as the standard.

Any drug or medicine recognized by the pharmacopœia is said to be *official*, which term has largely replaced the term *officinal*, which up to the present century was used to convey the same idea.

THE UNITED STATES PHARMACOPŒIA AS A BOOK

Before taking up the monographs of the pharmacopœia on individual drugs, it is well to devote a short space to the work as a whole, and this can best be done by copying in its entirety information found in our national standard relating to three typical officials.

In the comparative table on p. 22 (*a*) is the Latin name, (*b*) the English name, (*c*) the synonym, (*d*) the official abbreviation, (*e*) the official definition, (*f*) the official description, (*g*) the official preparations and (*h*) the official dose. In case of preparations, the recipe for compounding is usually given, as (*e*), under Tinctura Lavandulæ Composita.

These several parts of the pharmacopœial monograph on a drug can best be discussed in regular order.

The **Latin name** is placed first in the United States Pharmacopœia for the several reasons that are given in discussing the use of Latin in prescriptions (p. 929) and the name chosen is usually the simplest and clearest title found among the several Latin designations of the drug. In this respect our pharmacopœia is a great improvement over those of most other countries, where lengthy Latin titles seem the rule. In the pharmacopœia of our country but one word is used for the Latin name whenever possible; thus, it calls aconite "*Aconitum*," and not "*Tubera Aconiti*," as does the German Pharmacopœia, there being but one part of the aconite plant recognized by the United States Pharmacopœia; hence there is no confusion in the single name. Of course, one word as the Latin name would sometimes lead to confusion; thus, two parts of the colchicum plant are official—the root (or corm) and the seed. The single word colchicum immediately gives rise to the question, "which part of colchicum?" hence, in such cases to the Latin word is added the name of the part, viz., Colchici Cormus and Colchici Semen. Again, as another case, there are two mints official—the herbs, *Mentha Piperita* and *Mentha Viridis* respectively. To call either *Mentha* would be confusing, hence the Latin titles of the two are as just given. In choosing the Latin name of a vegetable drug the United States Pharmacopœia usually selects the generic name (p. 24) of the plant from which it is derived, one exception being Casara Sagrada, the botanical name of which is *Rhamnus Purshiana*. Among the chemicals, the same simplicity obtains in the United States Pharmacopœia, although, as it is impossible to express the idea of acids and salts in less than two words, one-word Latin names are less frequent. Lime is given the Latin name *Calx* in

(a) **TARAXACUM**

(b) **Taraxacum**

(c) **Dandelion**
(d) **Tarax**

(e) The dried rhizome and roots of *Taraxacum officinale* Weber (Fam. *Compositæ*). Preserve the thoroughly dried drug in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride from time to time, to prevent attack by insects.

(f) Cylindrical or somewhat flattened, gradually tapering, usually in broken pieces, from 6 to 15 cm. in length and from 5 to 15 mm. in thickness; externally brown or blackish-brown, longitudinally wrinkled, having numerous root and rootlet-scars; crown simple or branched with numerous leaf-bases showing annulate markings; odor slight or inodorous; taste bitter.

Under the microscope, transverse sections of the root of Taraxacum show a porous, pale yellow wood from 1 to 4 mm. in diameter, surrounded by a light brown bark from 2 to 6 mm. in thickness, the latter composed of concentric layers of laticiferous vessels and sieve tissues, alternating with whitish inulin-bearing parenchyma. The rhizome portions show a small pith.

The powder is light brown; when examined under the microscope it exhibits parenchyma cells which are large, thin-walled and containing irregular masses of inulin; fragments with yellowish-brown laticiferous vessels; tracheæ reticulate; intermediate fibers nonlignified, with irregular, simple and oblique pores.

Taraxacum yields not more than 10 per cent. of ash.

(g) *Preparations.*—Extractum taraxaci. Fluidextractum taraxaci.

(h) *Average Dose.*—Metric, 10 Gm.—apothecaries, 2½ drachms.

SULPHUR SUBLIMATUM

Sublimed Sulphur

Flowers of Sulphur
Sulphur. Sublim.

It contains when dried to constant weight in a desiccator over sulphuric acid, not less than 99.5 per cent. of S (32.07).

Sublimed sulphur is a fine, yellow powder, having a slight, characteristic odor, and a faintly acid taste.

Sublimed sulphur is practically insoluble in water and nearly insoluble in alcohol; it is slightly soluble in ether; soluble or partially soluble in carbon disulphide, chloroform, or olive oil.

At about 115°C. it fuses to a yellow, mobile fluid, which upon further heating becomes dark and viscid. In the air it burns to sulphur dioxide, characterised by its odor.

The amount of residue left after volatilising or igniting a weighed portion of well-dried sublimed sulphur does not exceed 0.5 per cent.

Assay.—Transfer about 1 Gm. of sublimed sulphur, previously dried to constant weight in a desiccator over sulphuric acid and accurately weighed, to a flask containing 50 mils of a 10 per cent. solution of potassium hydroxide. Boil the mixture until the liquid is of a transparent, golden-yellow color and then dilute it with distilled water to make a volume of exactly 250 mils. Oxidise 25 mils of this diluted solution by the addition of solution of hydrogen dioxide in excess (using about 50 mils), and heat on a water bath for thirty minutes. Then acidulate the liquid with hydrochloric acid, and dilute it with 100 mils of distilled water. Now heat it to boiling and add hot barium chloride T.S., in small portions, to the resulting liquid until no further precipitation takes place. Heat this mixture on a water bath for thirty minutes, collect the resulting precipitate on a filter, wash, dry, ignite, and weigh the barium sulphate. Carry out a blank determination using the same amount of all of the reagents but omitting the sulphur, and before making the final calculation deduct the amount of barium sulphate thus obtained from that obtained in the assay. It shows, in the dried product, not less than 99.5 per cent. of S.

Each gramme of sublimed sulphur, previously dried, corresponds to not less than 7.243 Gm. of barium sulphate.

(g) *Preparation.*—Unguentum sulphuris.

(h) *Average Dose.*—Metric, 4 Gm.—apothecaries, 1 drachm.

TINCTURA LAVANDULÆ COMPOSITA
Compound Tincture of Lavender
Compound Spirit of Lavender
Tr. Lavand. Co.

Oil of Lavender, *eight milliliters*	8 mils
Oil of Rosemary, *two milliliters*	2 mils
Saigon cinnamon, in No. 50 powder, *twenty grammes*	20 Gm.
Clove, in No. 50 powder, *five grammes* .	5 Gm.
Myristica, in No. 50 powder, *ten grammes* .	10 Gm.
Red saunders, in No. 50 powder, *ten grammes*	10 Gm.
To make *one thousand milliliters*	1000 mils

Prepare a tincture by type process M (see p. 222), macerating the powders in a mixture of *seven hundred and fifty mils* of alcohol, in which the oils have been dissolved, and *two hundred and fifty mils of* water. Complete the preparation with a mixture of *three volumes* of alcohol and *one volume* of water.

Liquor potassii arsenitis.

Average Dose.—Metric, 2 mils—apothecaries, 30 minims.

the United States Pharmacopœia, against *Calcaria Usta* of the German Pharmacopœia, but potassium iodide can be expressed in Latin no more simply than *Potassii Iodidum* of the United States Pharmacopœia. As in vegetable drugs, there are some cases where extra words are needed to avoid confusion. Thus, there are three official forms of ferrous sulphate—crystals, granulated, and dried. In this case the crystals are called *Ferri Sulphas*, the granulated is called *Ferri Sulphas Granulatus*, and the exsiccated is called *Ferri Sulphas Exsiccatus*. Likewise, there are two official mercury chlorides, the comparatively innocuous calomel and the very poisonous corrosive sublimate; hence it is very necessary to distinguish accurately between them. Therefore to the simple Latin phrase *Hydrargyri Chloridum* is added the qualifying adjective "*Mite*" in the case of calomel, and "*Corrosivum*" when corrosive sublimate is meant. In writing these Latin names the accepted rules of Latin grammar are followed, as will be shown later (Chapter LVII). Here it suffices to say that all the Latin names of drugs are placed in the singular number —as galla, not gallæ, for galls; caryophyllus, not caryophylli, for clove— this, according to the United States Pharmacopœia of 1850, "following the example of the Roman medical writers."

English Name.—In choosing the official English name for the drug the revisers have not bound themselves to the most popular English designation for the same; in fact, as a rule, the popular names have been relegated to the class of synonyms, and in many cases as the English name has been chosen a term by which they are rarely known by the public; the official Latin and English names being very frequently the same. Thus, *Serpentaria* is given as both the Latin and English name of what is commonly known as *Virginia snakeroot*, and the latter term is used as the synonym. In choosing the English name, however, the same care and judgment were used as in the selection of the Latin name, and where the common English name is shorter than the Latin term and is sufficiently distinctive to preclude danger of confusion with other drug names, it is then chosen; thus, "clove" is used instead of the Latin *Caryophyllus;* "ginger," instead of *Zingiber;* "elm," instead of *Ulmus*.

In choosing the English name of chemicals, the nomenclature of the Geneva International Conference on chemical names has been followed in many cases, the aim being to be thoroughly modern without being ultra-advanced. Of this nomenclature of salts, particular reference will be made in Chapter XXII, so here need only be said the advisability of the student accustoming himself to the modern naming at the outset of his studies. Thus, learn to use the modern term "potassium chlorate" instead of the antiquated title "chlorate of potassium," or, worse yet, "chlorate of potash."

Synonym.—Under this head the pharmacopœia places those drug names too popular to be ignored, and which, for various reasons, could not wisely be accorded official preference.

The term "Virginia snakeroot" is almost universally employed instead of the official English name, "Serpentaria," but the pharmacopœia exercises selective preference for the latter word because the word snakeroot is applied to several distinct drugs, among them being: serpentaria: cimicifuga, or black snakeroot; caulophyllum, or Samson snakeroot; asarum, or Canada snakeroot; sanicle, or black snakeroot; eryngo, or button snakeroot; and senega, or seneka snakeroot. It is clear, therefore, that the designation snakeroot immediately raises the query, "which snakeroot?" hence the pharmacopœial aim to eventually do away with these confusing synonyms. Again, the use of the common synonyms is apt to bring misleading results by similarities in same. Thus, in one case, instead of calamus, recommended for the gums of a teething infant, calomel was purchased and applied. So the example set by the United States Pharmacopœia should be followed as far as possible by the retail pharmacist, who should endeavor gradually to educate his trade to the official English name instead of the misleading and confusing synonym.

Official Abbreviation.—This innovation, the insertion in the pharmacopœial text of abbreviations of the Latin names of the medicines, is a needed reform the practical working of which will be followed with much interest.

Official Definition.—This tells what the drug is, and the United States Pharmacopœia does this in as few words as possible, as reference to the three typical cases given on the preceding page will show. Accordingly, as the drug is of vegetable or of mineral origin, the definition differs; in the first case, the botanical name of the drug yielding the drug plays a leading rôle in definition, whereas with chemical drugs the symbolic chemical formula is frequently the entire definition. Hence it is profitable to discuss these two entirely different means of description separately.

Botanical Name.—Thanks to the science of botany, all the 175,000 plants known to the civilized world have been carefully studied, accurately classified, and to each has been given a distinctive scientific botanical name. This botanical name is of Latin form, and follows the rules of Latin grammar. It often seems unnecessarily long and difficult, but, as will be later shown, from time to time, it is usually aptly chosen, as by it we frequently can understand some of the characteristics of the plant. The botanical name of the plant generally consists of two words—the generic name, that common to the genus or plant group, and the specific name, peculiar to the one kind of plant under consideration, an adjective usually distinguishing it from closely similar plants.

Even to the English name of a plant we frequently have to add a qualifying adjective; thus we know two kinds of oranges, and to distinguish them we call one bitter orange, the other, sweet orange; so do they in Latin, the sweet orange being *Citrus Aurantium sinensis*, the bitter, *Citrus Aurantium amara*. The lemon is very similar to the orange, hence is given the same generic name, its complete name being *Citrus Medica Limonum*. In fact, botanical names are very much like our personal names. We are Smiths and Jones and Browns because we belong to these families, and in order that one Smith may be distinguished from another, we call each by what is known as a given (or Christian) name—Tom, Dick, or Harry. The difference between the personal names of men and the botanical names of plants is that in plants the specific name, the plant's "Christian name," is put last instead of first, as if we would call ourselves Smith John, instead of John Smith.

Do not misconstrue the above comparison of the family name Smith to the botanical name Citrus into the idea that the word Citrus is the family name of the plant. It is the name of the *genus;* a plant *family* being much broader, and including many genera.

As to the writing of the botanical name, the generic name always begins with a capital letter, while the specific name is written with a small initial letter, except in three cases: (1) When the specific name has been at one time the generic name; (2) when derived from the name of a person; (3) when an indeclinable noun. As seen above, in some cases, the specific name consists of two words; one designating the particular variety, when there are two or more varieties of the same species.

Following the botanical name in the United States Pharmacopœia and other standard works comes a proper name—as, "*Lactuca virosa*, Linné" or "*Pterocarpus Marsupium*, Roxburgh." This is the name of the botanist by whom the botanical name was bestowed upon the plants.

A glance through the pharmacopœia will show that a large number of plants were examined and named by Carl Linné (1707–1778), who was a Swedish apothecary. The botanical term *family*, mentioned above, and used in the present pharmacopœia, was scarcely happily chosen, and in common conversation it is better to use the word "tribe" instead. Scientists substitute for the word the term "natural order." For complete explanation of this plant grouping recourse should be had to a standard botany, so suffice it here to state that similar plants are grouped together into a *genus* (plural, *genera*); thus all the roses are grouped into the genus *Rosa;* the oranges and the lemons into the genus *Citrus;* the mints into the genus *Mentha*. Now, roses have some characteristics like those of the blackberries (or the genus *Rubus*), and, like the apples and pears (or the genus *Pyrus*). In such cases these similar genera are grouped together for classification into a natural order; in that under consideration the name chosen for the natural order is *Rosaceæ*. Similarly, the daisies (genus *Bellis*), the sunflowers (genus *Helianthus*), the dandelions (genus *Taraxacum*), and many similar genera are grouped into one natural order called the *Compositæ*. It will be noticed in the United States Pharmacopœia the botanical name is always followed by the name of the natural order (or family).

Symbolic Formula.—A majority of the official chemicals are not derived from plant sources, hence in defining same a botanical name has no part, and a symbolic chemical formula is used instead.

A full explanation of a chemical formula will be given later, so sufficient for this place is the bare mention that it is an abbreviated method of expressing the composition of the chemical.

Thus the formula $NaCl$ means a compound consisting of one atom of the element sodium and one atom of chlorine to each molecule. K_2SO_4 means a compound containing two atoms of potassium, one atom of sulphur, and four atoms of oxygen to the molecule. Hence it can be seen that the chemical formula answers in place of a definition of many words. Moreover, by means of the symbolic formula we learn the exact composition of the official chemical. Thus, while absolute sodium sulphate is really Na_2SO_4, that is, it consists of two atoms of sodium, one atom of sulphur, and four atoms of oxygen to the molecule, the pharmacopœia gives as its symbolic formula, $Na_2SO_4 10H_2O$, showing that the official product is sodium sulphate combined with ten molecules of water of crystallization (Chapter XXVI).

The official definitions of chemicals in the present pharmacopœia are longer than those of former pharmacopœias, because of introduction of the so-called "*Purity Rubric.*" This includes a specific mention of the amount of absolute chemical contained in a commercial sample. Thus, sublimed sulphur (p. 22) "must contain not less than 99.5 per cent. of S (32.07)." This purity rubric was introduced to define accurately the chemical for purpose of its identification under the Food and Drug Laws, both State and national. To say that sublimed sulphur is $S = 32.07$, would imply a 100 per cent. product, which is practically impossible to obtain. Since the rubric directs "not less than 99.5 per cent.," ½ of 1 per cent. of accidental impurity, say, moisture, is permissible.

The figures in such cases as "S (32.07)" cited above represent the atomic weight of an element or the molecular weight of a compound (p. 349).

Official Description.—This division of the pharmacopœial treatment of official drugs scarcely needs extended comment, so clear and concise are the descriptions. They are inserted to enable the pharmacist to find out whether the drugs and chemicals he purchases are really of quality worthy of administering as medicine. With vegetable drugs, the description deals with the external and microscopic appearance, and in cases of some of the more potent drugs, a method of estimating the quantity of the active ingredients is given, this method being called the *assay of the drug*. With chemicals, the official description deals with appearance, solubility, and other physical characteristics, and is supplemented by a series of chemical tests, first, to establish the identity of the chemical, and, secondly, to detect the presence of impurities. Lastly, there is usually given a quantitative assay of the chemical by means of volumetric or gravimetric analysis.

The neglect of the average pharmacist to compare his stock of medicines with the standards established·by this pharmacopœial description is not only unwise, but also unsafe, for, aside from the ethical point that the pharmacist should never dispense a drug unless he personally knows that it is up to all pharmacopœial requirements, there is the selfish ground that in most of the States laws relating to the purity of drugs are in force and nothing is more fatal to the reputation of a druggist than prosecution for selling inferior drugs.

Method of Preparation.—Of the 782 medicines recognized by the United States Pharmacopœia, in the case of over half the method of preparation is given, the policy being to give a recipe whenever it is practical for the pharmacist to compound the remedy. For heavy chemicals, which can be made much more cheaply by the large manufacturer than by the retailer, no recipe is given, and as the pharmacopœial committee has carefully considered this question, it behooves every self-respecting pharmacist to make as many of the preparations for which a recipe is given by the United States Pharmacopœia as he possibly can.

The recipes of the United States Pharmacopœia are the result of careful study, and are as near perfect as human ingenuity can suggest. Occasionally an unpractical recipe slips in, but in most cases where a recipe yields an unsatisfactory product the fault lies with the manipulator, rather than with the framer of the recipe. In all recipes of the ninth edition of the United States Pharmacopœia the metric system of weight is directed to be used, the transition from the old system occurring in the revision of 1880 and 1890, as can be noted by comparing the change in weights and measures in the pharmacopœias of 1870, 1880, and 1890:

1870. Troy ounce and fluidounce.

1880. Parts by weight (both solids and liquid weighed). This was done because of the strong desire to change from the old system—troy ounces and fluidounces—to the metric system.

However, the opposition to the innovation proved too strong, and, as a compromise, parts by weight were chosen. According to this, a preparation could be made either in avoirdupois ounces, troy ounces, avoirdupois pounds, troy pounds, grammes, or kilogrammes. Thus, in the formula of Ammonia Liniment (1880) which read—

Water of ammonia	30 parts
Cotton-seed oil	70 parts

if we used ammonia water, 30 tr. oz., 30 av. oz., or 30 Gm., we would add respectively of oil, 70 tr. oz., 70 av. oz., or 70 Gm., giving everybody a chance to use his pet system of weights.

It proved, however, a bunglesome piece of work, for it was an awkward matter to weigh, for instance, 100 Gm. of a percolating tincture, but it accomplished its work. It established the idea of decimal ratio, and 1890 found the convention ready to adopt the metric system.

Since 1890. The metric system—grammes and cubic centimeters.

Official Preparations.—In the present pharmacopœia, the description or method of preparing an official product is followed by a list of those preparations of which it is an ingredient, a matter of much convenience to the student.

Average Dose.—As explained in the preface to the pharmacopœia, the dose given in most of the monographs on official products is intended purely as a guide to the practitioner and the dispenser. Efforts were made at the convention of 1910 to provide a table of maximum doses, beyond which the physician should not transgress, unless he emphasized his desire for heroic doses by writing out the amount in full or by other plain proof of his intention; but the proposition was voted down.

The National Formulary.—This work prepared by a committee appointed by the American Pharmaceutical Association is now a legal standard since the National Food and Drug Laws as well as most State laws, direct that the standards set for drugs and preparations found therein shall be employed in enforcing the several statutes. The fourth edition which has just appeared, contains not only a number of reliable recipes for well-known pharmaceuticals but also in Part II provides standards for all drugs used in making the preparations, when such ingredients are not recognized by the United States Pharmacopœia.

DISPENSATORIES

A pharmacopœia, being intended as a concise standard work of reference, by no means embraces all the material used in the healing art. Thus the ninth revision, United States Pharmacopœia (abbreviated U.S.P. IX), recognizes 782 drugs and chemicals, and these include scarcely a tenth of the remedies that have been suggested even in our country, exclusive, of course, of the nostrums. The officials represent those remedies which, in the judgment of the revision committee, are indispensable in the practice of medicine: those remedies singled out from the vast number as being really valuable. Even of official products the barest details are given by the various pharmacopœias in the effort to prevent these works from becoming too voluminous. Accordingly, in the various civilized countries there early sprang up the need of commentaries on the pharmacopœia: large works which not only fully described the official remedies, but also made mention of a large number of the unofficial drugs and chemicals used in medicine.

In this country such commentaries are called *dispensatories*, and we are provided with three valuable works of this character: The United States Dispensatory, first published in 1833, the National Dispensatory, first published in 1879, and King's American Dispensatory, first published in 1854.

BIBLIOGRAPHICAL HELPS

Among appliances needed by the druggist, none are more necessary than a well-selected library of books and journals, for it is from these that he learns the basic principles of his calling. In the preface will be found a list of such books and journals consulted by the author, with the abbreviations used in the bibliography found at the end of each chapter.

As to books, these can be divided into three groups: (*a*) standard official works like the several pharmacopœias and The National Formulary; (*b*) "source books" distinguished by reason of their wealth of bibliographic references; and (*c*) books that are of service to the everyday druggist because of the practical information they offer on special lines. A suggestive list of this class is found in the *Druggists Circular* for April, 1914. As to "source books," most of those given in the bibliography found at the end of each chapter of this work are of that nature. In such, the seeker after the original articles can find the references to the papers he wishes to consult. Similar service is rendered by the Proceedings of the American Pharmaceutical Association volumes 1 to 60 (1851 to 1911) and in their successors the "year books" of the association. In current chemical literature, *Chemical Abstracts* published by the American Chemical Society is likewise of tremendous value, since therein is found abstracts of practically every article published in every chemical journal on the work.

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CHAPTER II

METROLOGY

METROLOGY is the science of weights and measures.

The definition of *weight* as commonly used, to express the quantity of a given substance, is erroneous, the correct word for the absolute quantity of matter in a given substance being *mass*.

Thus the mass of a substance is unchangeable under all circumstances, while the weight varies under certain influences, since weight is the measure of the gravitating force of the earth, and the gravitating force of the earth varies at different points on the earth's surface and interior.

Details of gravity can be found in any elementary physics, so suffice it to say that all substances attract other substances in direct proportion to their mass, and since of all bodies on the surface of the earth the mass of the earth is infinitely greater, the preëminent attraction is that of the earth.

That the earth attracts bodies to it is shown by every falling object, the tendency of the falling object being to attain as near the center of the earth as possible. An ocular demonstration of the quantity of gravitating force is offered by the Jolly spiral balance (Fig. 1), which consists of an exceedingly sensitive steel spring, which is elongated on placing at the end thereof a weight which is attracted downward by the earth's force. The application of this spiral balance is seen in the ordinary spiral butcher's scale or ice scale. Such a balance measures directly the force of gravitation, and hence the weight of the substance, since weight is the measure of the gravitating force of the earth.

The same spiral balance can be used for measuring the comparative weights of various substances at the same place on the earth's surface, but since the measure of gravitation varies at various points on the surface of the earth, such balances are intended for use only at the place for which they are standardized. Thus, a body which is attracted toward the earth with a force of 192 pounds at the poles, is attracted with about a force of 191 pounds at the equator. Hence, as stated above, the weight of a substance is not an absolute criterion of its quantity, and we should learn to speak of mass rather than of weight.

In measuring the quantity of substance, three systems of units may be employed—those of length, capacity, and weight—and while these systems seem to have been introduced in the order named, yet their origin is so ancient as to be lost in the mists of prehistoric days, the Jews claiming that both weights and measures were introduced by Cain.

As to measures, the most ancient is the Egyptian cubit—the length of the forearm (B.C. 2300).

The *foot* is of Grecian origin, legend saying that Hercules' foot served as model. *Inch* is of Roman origin, being an "*uncia*," or twelfth of a foot, and to the same people we are indebted for the *pace* and the *mile* (*millia passum*). The *yard* is more modern, being the Anglo-Saxon measurement of the girth.

Of weights, the oldest specimens now extant are those excavated from the ruins of Babylon and Nineveh; one of these, a stone duck, from B.C. 2007, is inscribed as representing ten "*manah*." This manah was evidently the standard for all neighboring countries, mention of it being made in the Bible. This manah was divided into 60 shekels, and weighed, in some cases, about one avoirdupois pound (489 to 502 Gm.), while others weigh exactly twice as much.

This Babylonian manah was adopted by the Grecians, undergoing variations in weight during the lapse of years. Thus we find the city of Athens had a manah (or "mna," as they called it) weighing $15\frac{1}{3}$ avoirdupois ounces (436 Gm)., and the same people had a silver coin weighing $\frac{1}{100}$ of the manah, which they called drachma.

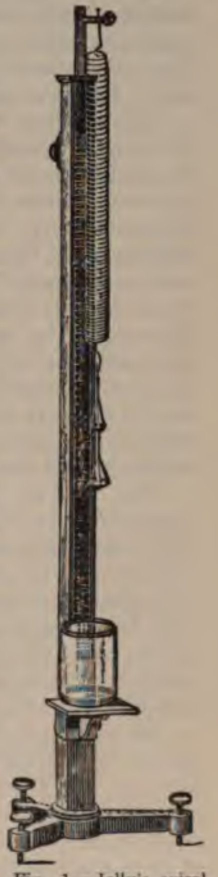


Fig. 1.—Jolly's spiral balance.

The weight standards of ancient Italy seemed also based on the Babylonian manah, the first coins from Rome being masses of bronze weighing about one-third the heavy manah, and called the "*as libralis*," or "*pondo libralis*." This Roman pound was divided into halves, thirds, quarters, and twelfths, and the latter was called "uncia"—hence our word "ounce." Of the same monetary value of the bronze coin "as libralis" was a small silver coin weighing about twenty of our grains (1.137 Gm.), and this was called a "*scripulum*," and as time went on these coin weights became the standard weights of the nation, and so it was that at the time of Nero the Roman weights were a *libra*, or pound of 327 Gm.; $\frac{1}{12}$ libra, or *uncia;* $\frac{1}{8}$ uncia, or *drachma;* and $\frac{1}{3}$ drachma, or *scripula*, practically our present apothecary system.

Concerning weights smaller than the scripula there is much confusion, different authorities mentioning the *obulus*, or $\frac{1}{2}$ scruple; the *siliqua*, or $\frac{1}{3}$ obulus, and the *chalkus*, or $\frac{1}{13}$ obulus, or $\frac{1}{5760}$ pound. This is of no special interest to us, and is mentioned merely to note the absence of the grain weight, although the siliqua (like our grain) was the weight of a seed—that of the plant *Ceratonia siliqua*, or St. John's bread.

The Roman weights were borrowed by all the countries of Central Europe, and likewise we find the coins of the middle ages were copies of those of Constantine the Great, whose Eastern Empire was a direct offshoot of the Roman. Thus the earliest Anglo-Saxon penny was an exact copy of Constantine's "tremisse," and weighs ⅓ scripula, or 24 grains, and the same is true of the penny of Alfred the Great. Evidently, this coin began to vary in weight, and to standardize same by some familiar unit was the aim of Henry III., whose statute of 1266 says the penny "shall weigh 32 wheat corns in the midst of the ear, and 20 pence do make an ounce, and 12 ounces one pound, and 8 pounds do make a gallon of wine, and 8 gallons of wine do make a London bushel." This famous statute is our formal introduction to our present system of weights and measures, giving us the first authentic reference to the pennyweight. The pound here mentioned is the ancient Tower pound, used from Anglo-Saxon times, and weighing but 5400 of our present grains.

The ordinance of Edward I. (1304) reiterates the statute just given, directing a penny of 32 grains of wheat, the ounce of 20 pence, the pound of 12 ounces, the gallon of 8 pounds of wine, and the bushel of 8 gallons. It also contains the innovation that a pound of money and of medicine consist of only 20 shillings; a pound of all other things consists of 25 shillings. It furthermore adds that a pound of money contains 12 ounces, while a pound of all other things contains 16 ounces; that is, that articles of a common character should be dispensed with more lavish hand than those which were more expensive. Following this idea, this new system of weights for the coarser commodities was called "avoirdupois," from the French words "*avoir*" and "*pois*," which mean "to have weight." Hence the origin of two different pounds and two different ounces, thus entailing upon English-speaking people even to this day material inconvenience and discomfort.

But whence the change from the penny of 32 wheat grains to the penny of 24 of our present grains? No statute authorizing a penny of 24 wheat grains can be found, unless we accept the testimony of a single and somewhat questionable authority, that a statute of Edward I. of the year 1280 directed a penny of 24 grains. The same authority believed that our present grain is the weight of a barley corn, rather than a wheat grain, and this may be the truth, since the grain of wheat of modern times has been found to weigh only three-quarters of our modern grain, and likewise only three-quarters the weight of a barley-corn.

Be this as it may, it seems possible that our modern grain is a foreign weight replacing the wheat grain, just as our two pounds (troy and avoirdupois) are foreign units which gradually forced the ancient English standard, the Tower pound, from the field.

The first official record we have of the introduction of foreign systems is in a statute of 1314, where the phrase "pur la libre de *troy* orre" is used, this ordinance directing the price of metals by the troy pound; while a statute of 1335 authorized merchants to buy and sell "corn, wine, *avoirdupois*, flesh, fish," etc.; the word in this case has its original meaning of "weight articles," and it was not until a statute of 1529 that mention of "the weight called haverdupois" is made.

Of these two systems, the troy is supposed to have been the standard of the French city of Troyes, which was quite a commercial center in medieval days, while our present avoirdupois pound is said to have been the standard of Bayonne, another city of France.

The United States standard yard and troy pound date from 1760, they having been conferred upon the colonies by the mother country, and are copies of the ancient weights given above, and no change has been made by this government since its organization.

The exact number of grains in a gallon of distilled water has been the source of much controversy and varying values are given. One source of variation is the matter of temperature and of barometric pressure at which the estimation is made. Thus in the present pharmacopœia it is stated that the value taken at 25°C. and at 760 millimeters pressure is 58,185 grains, while at 4°C. and *in vacuo*, it is 58,416.6 grains. Of course, the weight of the pint and of fluidounce varies according to which figure is taken for the gallon.

In 1816 and in 1836 the British government modified its system of weights and measures, adopting the so-called Imperial system, in which an effort was made to place the accepted system of weights and measures on a scientific basis by comparing same with physical units which can be easily verified. Thus, the yard of 36 inches is based on the length of a pendulum beating seconds in a vacuum in London at 62°F. The length of this pendulum is 39.1393 of the accepted historic standard inches, and 12 of these inches are called a foot, and three feet, a yard. In other words, the Imperial inch and yard are the same lengths as the old units, but their determination has been placed on a careful physical measurement. In like manner the Imperial troy pound remains at the old standard, 5760 grains. The grains, however, were carefully determined by the weight of a cubic inch of distilled water, the weight of which at 62°F., and at 30 inches barometric pressure was found to be 252.458 grains. The Imperial gallon differs from the United States gallon, being the volume of ten avoirdupois pounds of distilled water under standard conditions of temperature and barometric pressure. In other words, it is the weight of 70,000 grains of distilled water, and has the capacity of 277 cubic inches.

The volumetric subdivision of the Imperial gallon is also different from the United States gallon, it being divided, as ours, into 8 pints, but the pints are divided into 20 fluidounces instead of 16.

In our present United States system of weights and measures the troy, apothecaries', and avoirdupois ounce weights, and the yard and inch, are the same as the English, but the gallon, as the old English gallon of 1760, has a weight of 58,252.8 grains, and a capacity of 231 cubic inches.

The tables of weights and measures used in the United States are:

APOTHECARIES' WEIGHT.		ABBREVIATED.
20 grains	= 1 scruple	℈
3 scruples	= 1 drachm	ʒ
8 drachms	= 1 ounce	℥
12 ounces	= 1 pound	℔

TROY WEIGHT.		ABBREVIATED.
24 grains	= 1 pennyweight	dwt.
20 pennyweight	= 1 ounce	oz.
12 ounces	= 1 pound	lb.

AVOIRDUPOIS WEIGHT.		ABBREVIATED.
437½ grains	= 1 ounce	av. oz.
16 ounces	= 1 pound	av. lb.

U. S. FLUID MEASURE.		ABBREVIATED.
60 minims	= 1 fluidrachm	f ʒ.
8 fluidrachms	= 1 fluidounce	f ℥.
16 fluidounces	= 1 pint	O.
2 pints	= 1 quart	qt.
4 quarts	= 1 gallon	Cong.

The résumé of the old system of weights and measures shows what confusion prevails. We see there are four distinct *ounces: avoirdupois*, 437½ grains; *apothecary* or *troy*, 480 grains; *U.S. fluid*, 454.6 grains of distilled water; *Imperial fluid*, 437.5 grains of distilled water. Likewise there are two pounds: *troy*, 5760 grains; *avoirdupois*, 7000 grains. There are also two gallons; *U.S. gallon*, 231 cubic inches (58,185 grains of distilled water); *Imperial gallon*, 277 cubic inches (70,000 grains of distilled water).

Particular emphasis should be laid on the distinction between the U.S. and the Imperial fluid measures, and the American pharmacist should never use an English graduate.

Another pharmaceutic detail worthy of notice is the fact that pharmacists purchase their goods by the avoirdupois and dispense them chiefly by troy system. It is, therefore, well to remember that an eighth ounce of morphine sulphate is not an eighth of a troy ounce, or 60 grains, but an eighth of an avoirdupois ounce, or 54.69 grains.

COMMON MEASURES

The following common measures, largely used in the household, are worthy of mention:

A teaspoonful is supposed to be 1 fluidrachm.
A dessertspoonful is supposed to be 2 fluidrachms.
A tablespoonful is supposed to be 4 fluidrachms.
A wineglassful is supposed to be 2 fluidounces.
A teacupful is supposed to be 4 fluidounces.

The words "supposed to be" are well chosen, since most of the spoons and other measures vary greatly as to size.

Remember that a drop is not a minim, and a minim does not necessarily weigh a grain.

Drops vary according to the character of the liquid which is being dropped, and also according to the surface from which the liquid is dropped. As to the first, the variation in size of drops is from 44 drops of syrup of acacia, 120 drops of laudanum, and 250 drops of chloroform to the fluidrachm. The size of the drop of the same liquid will vary accordingly as the surface from which the liquid is dropped is sharp or flat, or whether the orifice from which it is dropped is large or small. Thus, water dropped from the bottom of a gallon evaporating dish measures 18 drops to the fluidrachm, whereas the same water at the same temperature dropped from a glass rod of 1/40-inch bore gave 600 drops to the fluidrachm.

Efforts are now being made to introduce a standard dropper to deliver 20 drops to each gramme of water at 15°C. A tube having an orifice 3 millimeters in diameter will produce drops of this size.

THE METRIC SYSTEM

The confusion resulting from the use of units of the same name and of different values cited on preceding pages led to an effort to secure an international system of weights and measures. This movement was instituted by Prince de Tallyrand, who persuaded the French assembly to pass a bill providing for the collating of the various systems of weights and measures then in use in France, requesting the coöperation of the

British government, and assigning the formation of the new system, based on a universal standard, to the French Academy of Sciences. The French Academy took up the work, and the report of same was made into a law August 1, 1793. The next year the French government sent the United States government a copy of the new weights and measures, with the request that they be adopted by the infant republic; this request was communicated to Congress by President Washington in his message, January 8, 1795. In 1821 national attention was brought to the metric system by John Quincy Adams, who strongly urged the adoption of same by Congress, but nothing was done in that direction until 1866, when an act was passed legalizing the system in the United States, and directing that the same be used in the medical department of the army and navy and the marine hospital service. In recent years further progress in this direction has been attempted by strong pressure on Congress to pass laws to make the system compulsory, as well as legal. Such a bill did pass the House of Representatives in 1896, but was laid on the table, and nothing has been done since.

The metric system was based on an absolute unit, and from that absolute unit all other units were directly or indirectly evolved. The standard unit taken was the forty-millionth part of the earth's circumference around the poles, which was called a "*meter*."

This meter was divided into tenths, hundredths, and thousandths, which were called respectively decimeter, centimeter, millimeter. Multiples of the meter were also arranged. A cube, a centimeter each way, was taken as the unit of capacity, and called a *cubic centimeter*. The weight of this cubic centimeter of distilled water at 4°C. (at which temperature water attains its greatest density) was called *gramme*, and in this way, from the primal unit of length, the unit of capacity and the unit of weight were obtained.

Of course, denominations other than these three units were essential, and in all cases such units were based on the decimal scale, the change in units of length and the weight being marked by the prefixes deci-, centi- and milli- (Latin words meaning ten, one hundred, and one thousand), as mentioned above, and deka-, hecto-, kilo- (Greek words meaning ten, one hundred, and one thousand) for the higher units.

An examination of this table of fractions,—$1/1000$, $1/100$, and $1/10$—exactly like mills, cents, dimes, and dollars, will show similarity between the metric system and our currency:

10000.	Myriagramme.	
1000.	Kilogramme.	
100.	Hectogramme.	
10.	Dekagramme.	
1.	Gramme.	Compare this to $1.00 (dollar).
0.10	Decigramme.	Compare this to 0.10 (dime).
0.01	Centigramme.	Compare this to 0.01 (cent).
0.001	Milligramme.	Compare this to 0.001 (mill).

The unit of volume, the cubic centimeter, being very small, a thousand of these mils was adopted as a higher unit and was called a liter; hence, a cubic centimeter is a milliliter, or one-thousandth of a liter.

Careful measurements have shown that the cubic centimeter has not the same volume as has the thousandth part of the standard liter. While the difference is too trifling to be ordinarily considered the committee of revision of the present pharmacopœia decided to follow the lead of the government scientists and to use the word milliliter or "mil" in place of the term cubic centimeter.

Orthography.—The original French metric terms were "metre, litre, and gramme." These have been anglicized by the American Metric Bureau into "meter, liter, and gram." However, there is danger that the latter word, when written, may be mistaken for "grain," hence the United States Pharmacopœia has retained the French spelling "gramme," though accepting the American spelling of the other two units, meter and liter.

Of metric weights, we need only consider—

Kilogramme, 1000 grammes.
Gramme.
Milligramme, $^1/_{1000}$ gramme (0.001 Gm.).

The prefixes hecta, deka, deci, etc., should be clearly understood, but in practical work they are not used very often.

The conversion of ordinary weights and measures into the metric or *vice versâ* is not so hard as it first seems. All that has to be known is the troy, avoirdupois, and fluid tables and the following facts:

I. That a gramme equals 15.5 grains, approximately.
II. That a kilogramme equals 1000 grammes, and that a milligramme is the thousandth part of a gramme.
III. That one fluidounce of distilled water weighs, at 78° Fahrenheit, 454.6 grains.
IV. That a mil of distilled water weighs one gramme.
V. That a liter equals 1000 mils.

With the three tables of weights and measures, given on a preceding page, and the above five facts, any ordinary problem in pharmacopœial weights and measures can be worked.

Just an example or so:

(*a*) How many grammes in 4 avoirdupois ounces?
Answer: 1 av. oz. = 437.5 grains.
4 av. oz. = 4 × 437.5 grains = 1750 grains. 1750 grains.

Remember, the denomination "grains" is the bridge across which one passes from the region of the old system to the realm of the metric system.

1 gramme = 15.5 grains.

Therefore, in 1750 grains there will be as many grammes as 15.5 goes into 1750.

15.5)1750(112+
155
—
200
155
—
450
310

So you see there are about 113 grammes in 4 avoirdupois ounces.

In comparing this example with the tables given by the pharmacopœia it will be found that while the answer just given is 112.9 grammes, the true equivalent is 113.4. This is due to the fact that the exact value of the gramme is 15.432 grains.

If 1750 is divided by 15.432, the quotient will be 113.4. However, 15.5 is near enough for most practical pharmaceutic purposes.

(*b*) How many troy ounces in 72.5 grammes?
Answer: 1 gramme = 15.5 grains.
72.5 grammes = 15.5 × 72.5 = 1123.75 grains.

72.5
15.5 **1123.75 grains.**
3625 We are on the bridge. Now for the other side.
3625
725
1123.75 **1 troy ounce = 480 grains.**

Therefore, in 1123.75 grains there will be as many troy ounces as 480 goes into 1123.75—

480)1123.75(2.3+
960
1637
1440

So it is seen there are about 2$\frac{3}{10}$ troy ounces in 72.5 grammes.

(*c*) How many fluidounces in 120 mils?
Answer: 1 mil distilled water at 4°C. = 1 gramme.
1 gramme = 15.5 grains.
120 mils distilled water = 120 × 15.5 grains = 1860 grains.

15.5
120
1860.0

Again we are down to *grains*. 1860 *grains*.
1 fluidounce distilled water at 15°C. = 454.6 grains.
Therefore, in 1860 grains distilled water there are as many fluidounces as 454.6 goes into 1860.

454.6)1860.0(4.0+ fluidounces
18184
4160

Hence, in 120 mils there are somewhat over 4 fluidounces.

(*d*) How many mils in 1 pint?
1 pint = 16 fluidounces.
1 fluidounce distilled water = 454.6 grains.
16 fluidounces distilled water = 454.6 × 16 = 7273.6 grains.

454.6
16
7273.6 grains.

Here we are at the crossing! 7273.6 *grains*.
1 mil distilled water = 15.5 grains.
Therefore, in 7273.6 grains distilled water there are as many mils as 15.5 goes into 7273.6.

15.5)7273.6(469+
620
1073
930
1436

So it is clear that there are about 470 mils in one pint.

One other equivalent besides the five already given had better be mentioned.

A gramme is 15.5 grains: what then is the value of a *grain* in the metric system? That point is of value in dosage.

The dose of potassium bromide (15–30 grains) is easy to translate into one to two grammes. But how about strychnine sulphate (dose, $\frac{1}{60}$–$\frac{1}{30}$ grain)?

Here is where the value of a *grain* in *milligrammes* is needed.

1 gramme = 1000 milligrammes.
1 gramme = 15.5 grains.
1 grain = $\frac{10}{155}$ gramme.
Therefore, 1 grain = $\frac{10}{155} \times 1000$ milligrammes.

$$\begin{array}{l} 155)10000(64+ \\ \quad\ \ \underline{930} \\ \quad\ \ \ 700 \\ \quad\ \ \ \underline{620} \end{array}$$

Accordingly, one grain equals about 65 milligrammes, and the dose of strychnine sulphate is 1 to 2 milligrammes ($\frac{1}{60} \times 65$; $\frac{1}{30} \times 65$).

The following quantities, confusing to the student should be mastered by him.

1 grain is 65 milligrammes or 0.065 grammes.
½ grain is 32 milligrammes or 0.0325 grammes.
¼ grain is 16 milligrammes or 0.016 grammes.
⅛ grain is 8 milligrammes or 0.008 grammes.

WEIGHTS AND MEASURES

The instruments used in the pharmaceutic application of metrology are weights and measures, and the comparison of a given substance to the standard is performed on an instrument called a scale or balance.

The only form of scale with which the mass of a substance is estimated by actual gravity is the *spiral balance*, which consists of a delicate spring to which is attached a scale pan, the elongation of the spiral when a weight is placed in the pan being marked by the descent of an arrow attached to the lower part of the spiral. This needle moves against an index, and the elongation of the spring under influence of gravity can be measured and through this the weight of the body determined (Fig. 1).

The popular modification of the same principle is shown in the common butcher's scale and ice scale.

Pharmaceutic scales are modifications of the principle of a balance which is an application of the well-known mechanical device, the lever. The principle of the lever is very simple, consisting of a rigid bar and an oscillating point called fulcrum, with the power applied in such a way as to raise or otherwise move a weight, this principle being exemplified in the familiar illustration of a crowbar for raising heavy bodies, and acting on the well-known principle that the power applied to raise or move a weight is inversely proportional to the length of the arms of the lever; hence, the longer the arm on which the power is applied, the greater the weight it can raise, and in the same way if the fulcrum is situated exactly midway between the power and the weight, these must be exactly equal to produce a state of equilibrium. On this principle the balance operates, the same primarily consisting of a rigid bar oscillating on a central fulcrum called a knife-edge. From either end of the bar are suspended pans on which are placed respectively the power and the weight; the "power" in this case being the standard weight used in estimating the quantity of the substance. If the central knife-edge is situated exactly midway between the two, a standard weight will be balanced by exactly the same mass of substance desired placed in the other pan; if, on the other hand, the fulcrum is so placed that one arm of the beam is longer than the other, a standard weight placed in the pan suspended from the longer arm will weigh as many times the amount of substance in the pan placed on the short arm as the relative length of the arms.

For the purpose of studying pharmaceutic balances it is convenient to divide them into the following four classes:

- Single beam equal arm balances.
- Single beam unequal arm balances.
- Double beam unequal arm balances.
- Compound lever balance.

SINGLE BEAM EQUAL ARM BALANCES

Several requirements are stated by authorities as essential to a perfect prescription balance, the first being that *the point of suspension should be slightly above the center of gravity.* By the center of gravity is meant the point on which a given object will oscillate absolutely freely: that point at which the weight of an oscillating body is exactly compensated in every direction.

To place the central knife-edge exactly at this point is to make the balance so sensitive that time is lost in attempting to bring the beam into a state of rest.

To place the knife-edge below the center of gravity means that abnormal condition wherein there is a greater weight above the point of suspension than below, with the result that, at the first opportunity, the heavy part above will endeavor to invert itself.

Second, *the end knife-edges should be equidistant from the center, and all three should be on the same plane and parallel to one another.*

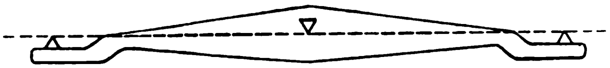


Fig. 2.—Position of knife-edges.

It is self-evident that if the beam is of exactly the same weight throughout, and an equal arm balance is desired, that condition can be obtained only by having one end knife-edge exactly the same distance from the central as the other. As the end knife-edges are usually inverted in relation to the central knife-edge, the effect of placing these knife-edges on the same plane is shown in the appended sketch (Fig. 2).

Third, *the beam should be of inflexible and light material.*

The lighter the beam, the less friction does it exert on the central knife-edge, hence a dictum in successful scale manufacturing is to make the frame as light as possible without sacrificing rigidity.

The knife-edges in ordinary prescription balances are of hard polished steel, but as that metal is liable to rust from contact with moist air, and since every particle of rust will increase the friction, rusted knife-edges oscillate less freely. In the finer forms of balance this impediment to free oscillation is prevented by making the tips of the knife-edges of agate, which does not rust.

Not desiring to fill this work with an excess of pictures which can be found in any catalogue of a manufacturer of pharmaceutic apparatus, only typical cases of the several forms of balances will be given.

Testing the Balance.—The testing of a balance to see whether the above requirements are met with is quite a simple matter. Thus, if a scale is sold as being sensitive to a certain weight, say $1/100$ grain, it should show its sensitiveness when such a weight is placed on a scale alone, and also when the scale is burdened with its limit of weight.

If the arms of the balance are exactly equal, the state of equilibrium produced by putting a hundred gramme weight on either pan should remain the same if these weights are exchanged.

If the knife-edges are parallel, moving the weights to various parts of the scale pans will have no effect on the equilibrium of the balance.

Hand Scales.—The simplest form of single beam equal arm balance consists of a beam with pan suspended on either end, the beam itself hanging from a ring held by the hand. In using a hand scale, the ring from which the beam is suspended should be placed on the first finger of the left hand, leaving the thumb and second finger to prevent too great oscillation of the index (Fig. 3).

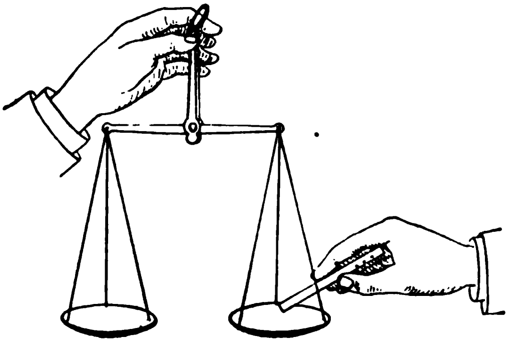


Fig. 3.—Holding hand scale.

Prescription Balance.—In this balance the beam is not suspended from the hand, but oscillates on a rigid upright column of brass through the center of which passes a lever by which the beam can be raised for oscillation, and lowered in a state of rest, at which time the knife-edges are not in contact with the oscillating surface, hence useless friction is avoided. The entire apparatus is inclosed in an appropriate glass case (Fig. 4).

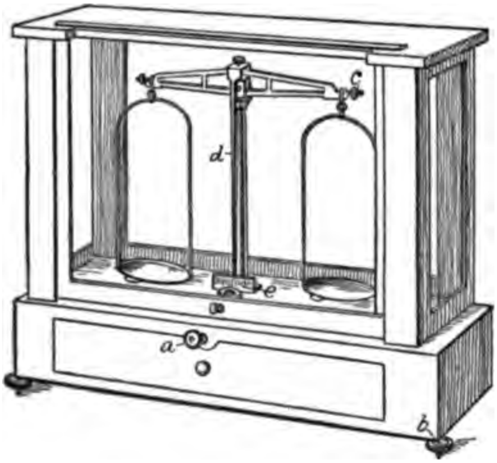


Fig. 4.—Prescription balance: *a*, Lever for raising beam; *b*, leveling screw; *c*, adjusting button; *d*, index needle; *e*, index.

In purchasing a prescription balance it is highly advisable to secure one which has a spirit-level and is provided with leveling screws, since to obtain accurate results in weighing it is essential that the balance be perfectly level.

After continued use it will be found that the weight of the two arms may vary, and thus throw the balance out of equilibrium, and to remedy this, the better forms of such balances have a beam on each end of which are buttons which move freely up and down a screw, thus making it easy to attain equilibrium.

Attached to the beam near the central knife-edge is the metallic needle, which, by its oscillation against the scale, shows when equilibrium is reached. This is attained when the needle, after oscillating, comes to rest at the point on the index directly beneath the point of suspension. To wait until a delicate balance ceases oscillating is a tedious operation, and therefore the pharmacist and chemist have recourse to the method known as reading the zero point, explained under the analytic balance.

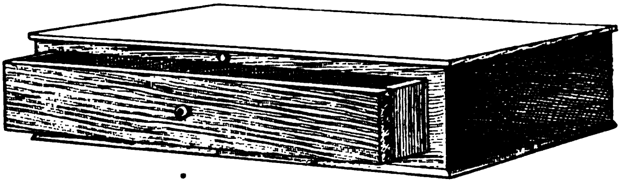


Fig. 5.—Army prescription scale (folded).

Army prescription balance is an exceedingly simple and convenient form of single beam equal arm balance, but not of sufficient accuracy to warrant general use in pharmacy. As suggested by the name, it is primarily intended for use by army surgeons and others who move from place to place, being of such manufacture that it can be easily dismantled and carried around in the drawer (Figs. 5 and 6).

Analytic Balance.—Merely a refined modification of the prescription balance. While the latter is sensitive to 1/30 grain, the analytic balance is sensitive to 1/20 milligramme, or 1/300 grain. In the analytic balance the beam is usually of aluminum, while the knife-edges are invariably tipped with agate.

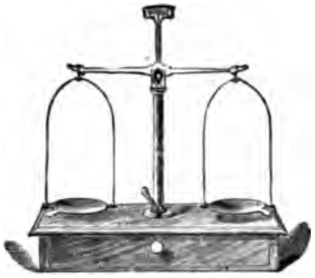
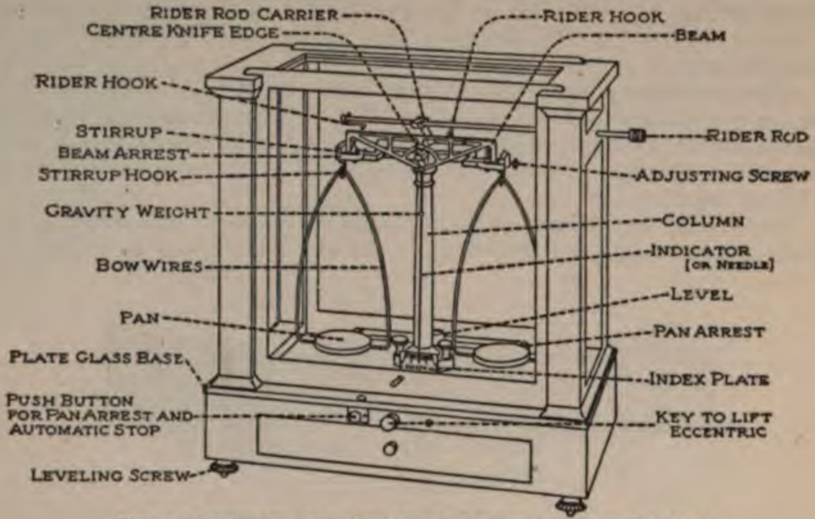


Fig. 6.—Army prescription scale.

For weighing a smaller quantity than a centigramme recourse is had to a rider weight. The rider, which usually weighs a centigramme, is so shaped as to straddle the beam, and therefore when placed on the beam, exactly over the end knife-edge, it will exert the weight of a centigramme. The distance on the beam from the end knife-edge to the central knife-edge is divided exactly into a hundred parts, and up and down the beam on the scale the rider can be moved. Following the principle of the lever, weights which will exert on the opposite scale pan, the force of 1 centigramme when placed exactly over the end knife-edge, will exert the force of but 1/2 centigramme if moved half way up toward the central knife-edge, and will exert the force of but 1/10 centigramme if moved nine-tenths of the way up toward the central knife-edge. The beam



BEAM ARREST AND COLUMN COMPRISE THE STAND

Fig. 7.—Analytic balance.

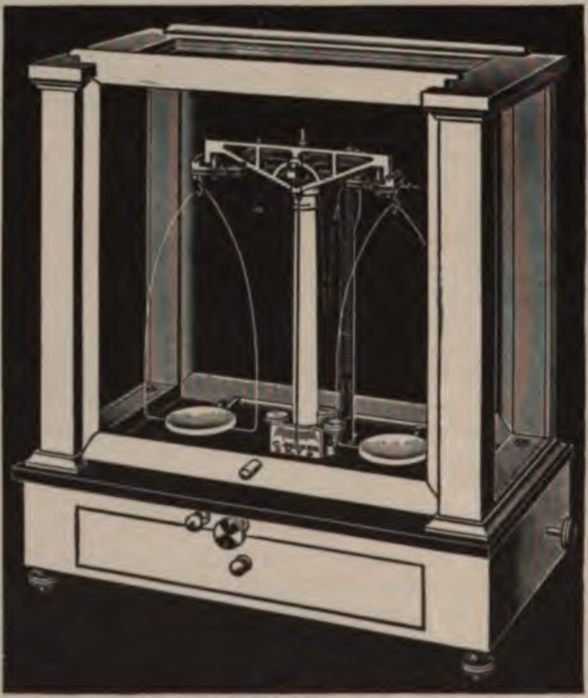


Fig. 8.—"Chainomatic" balance.

being divided into exactly 100 equal parts, the rider can be placed at any of these marks, and thus can be obtained on the other scale pan any part of 1/100 centigramme or 1/10 milligramme (Fig. 7).

Reading Zero.—Time is saved in estimating equilibrium by watching the oscillation of the needle against the index mentioned under prescription balances. The index scale on the analytic balance is usually divided into twenty equal lines, ten on either side of the line exactly below the point of suspension.

We set the beam in oscillation, when the needle will move to the left, left, say five lines, and then, if the beam is in equilibrium, the needle will move back to exactly the fifth line on the right. On the return the needle will go to almost the fifth line to the left. If, however, the index moves to the fifth line to the left and then returns to the second line to the right, it would indicate that the right beam was heavier than the left beam, and equilibrium must be restored by moving a button at the end of that beam.

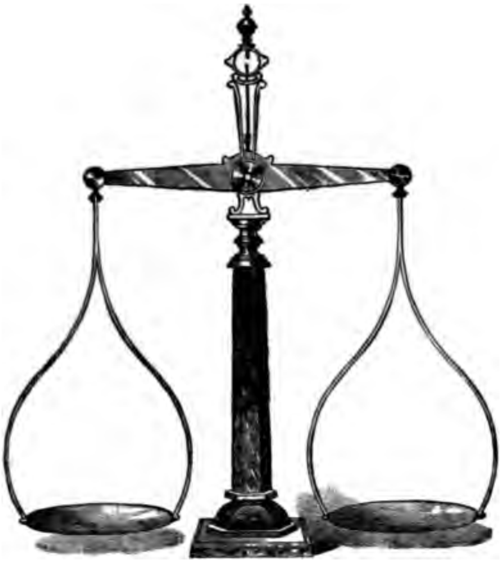


Fig. 9.—Marble-counter balances.

The careful estimation of weight by this means is called "interpolation," full details of which can be found in text-books on advanced physics.

A large form of single beam equal arm balance is found in the old-fashioned counter balance shown in Fig. 9.

SINGLE BEAM UNEQUAL ARM BALANCE

In this form of balance the beam, from which is suspended the weight, is usually two to ten times as long as the beam to which is attached the pan on which the substance is to be weighed. Thus the principle of action, as cited above, is that the standard weight is to the substance to be weighed as the length of the short arm is to the length of the long arm. Thus, on such a balance, in which the relative length is one to ten, a weight of one pound placed on the end of the long arm exerts a weight of ten pounds placed at the end of the short arm, and in such balance the weight is usually suspended directly from the beam, which is accurately divided into 100 parts as the beam of the analytic balance, the weight serving in this case the same purpose as the rider in the analytic balance.

An interesting type of such balance is found in the Chaslyn balance (Fig. 10).

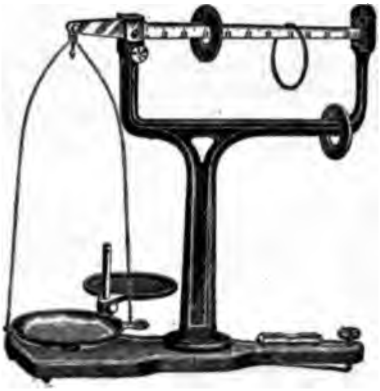


Fig. 10.—Chaslyn balance.

DOUBLE BEAM UNEQUAL ARM BALANCE

This balance is a modification of the preceding one, it being found convenient in many cases to have two beams instead of one, so as to handle two weights. Such a balance is particularly convenient when it is desired to know the tare of a utensil into which the weighed substance is to be placed (Fig. 11).

COMPOUND LEVER BALANCE

In this balance we find a series of levers replacing the single or double beam hitherto discussed, one lever acting on another. The more points of contact, the more the friction, and therefore such forms of balances are, as a rule, less accurate than the single beam; however, they are more durable, and, as a rule, weigh more quickly. Such a form of balance is seen in the usual box counter scale and the box prescription scale (Figs. 12 and 13).

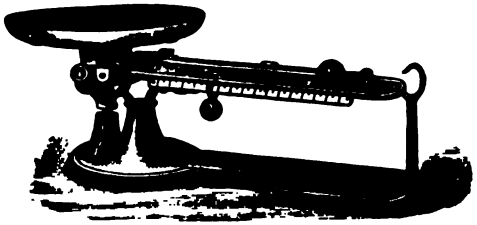


Fig. 11.—Troemner's ball scale.

In both cases the levers are so arranged that a weight placed on a scale is exactly compensated by the same weight on the other beam, hence to all intents and purposes the principle of action is the same as that of the single beam balance.

A modification of the compound lever balance is seen in the ordinary platform scale intended for weighing very heavy articles. In such cases the handling of weights equal to the mass of substance to be weighed would entail vast labor, so such compound lever balances are constructed on the principle of unequal beam balances, consisting primarily of two levers, on each of which the power is multiplied by ten. In such a balance the weight of one pound placed on the first lever exerts on the end of the second lever a force of ten pounds, and this force of ten pounds produces a force of 100 pounds on the end of the second lever on which the platform rests; hence on such platform scale a one-pound weight placed on the end of the index arm will exert the force of 100 pounds on the platform.

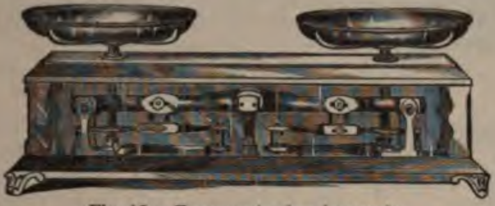


Fig. 12.—Troemner's glass box scale.

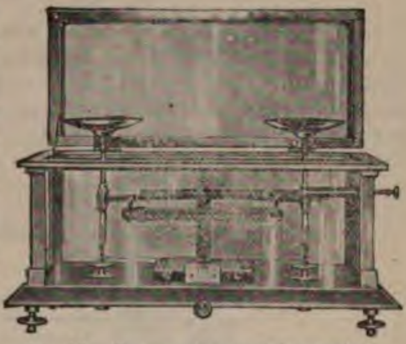


Fig. 13.—Troemner's prescription scales.

Torsion Balance.—As cited above, the chief objection to steel knife-edges is that when they rust, the friction is increased, with a corresponding loss of sensibility. This is obviated by the use of agate knife-edges, but that materially increases the cost of the apparatus (Fig. 14).

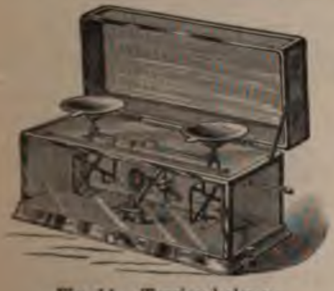


Fig. 14.—Torsion balance.

In the torsion balance knife-edges are dispensed with and, instead, the beam oscillates on a tightly drawn and twisted wire (Fig. 16).

CARE OF THE BALANCE

In the balance we have the most accurate physical instrument that has been devised, and also one which, under reasonable treatment, will last many years. In that event, however, due care must be taken to protect the balance from injury, and among the several points which must be enumerated are these:

First, the balance should be kept permanently in a dry room, the temperature of which is as even as possible, and protected from any acid or corroding vapors. In case it is necessary to weigh a fuming liquid, such a nitric acid, it should be placed in a well-stoppered bottle while weighing.

Second, such suggestions as not placing the substance to be weighed directly on the metallic pans, and keeping the pans free from all moisture, seem unnecessary to one who appreciates the value of a balance, and convenient for accomplishing these results are the movable glass scale pans which can be purchased from any scale manufacturer.

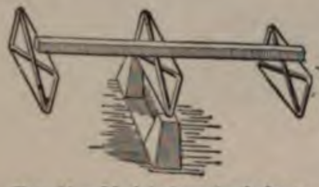


FIG. 15.—Model of torsion balance.

Third, weights should never be left on the balance, and, whenever possible, should be transferred to the balance by means of pincers.

Fourth, under no circumstances should the balance be left to oscillate after weighing is finished, and during the weighing it should be brought to a state of rest whenever new weights or a new substance is being placed thereon.

WEIGHTS

The weights used on scales and balances are composed of iron, brass, or aluminum, and of such shape as convenience suggests. Thus, the cheap avoirdupois weights are made of iron, while those finer are composed of brass, and the more expensive are nickel plated, and their shapes are usually those shown in Fig. 17.

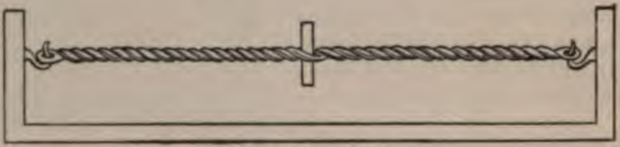


Fig. 16.—Effect of torsion.

The troy weights are usually made in sets nested, each weight, therefore, being a cup inclosing all the weights of smaller denominations than itself, the smallest, usually ¼ troy ounce, being solid, and fitting in a cup-shaped weight of the same denomination (Fig. 18).

As the avoirdupois weights, so the metric are composed of iron or brass; fine analytic metric weights are sometimes gold-plated brass and are sometimes platinum coated.

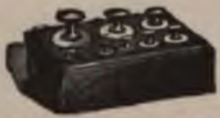


Fig. 17.—Brass block weights.

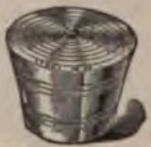


Fig. 18.—Troy cup weights (solid brass).

In purchasing avoirdupois and metric weights it is usually wisest to choose such as are arranged in a block. A very convenient form of such block is made of cast iron, the objection to wooden blocks being that they frequently swell, rendering it difficult to remove the weights.

The metric analytic weights should be in a fine wooden box, the depressions in which the weights rest being lined with velvet, serving the double purpose of keeping the weights from being scratched and preventing them being held fast by the swelling of the wood. The denominations under one gramme are made of sheet platinum.

For dispensing purposes troy weights are used, the denominations under ten grains being made of aluminum, either in sheets or in the form of wire, the latter being bent into as many sides as the weights have grains.

MEASURES

In pharmacy the larger measures, gallons, quarts, etc., are not often used, although reliable measures of these sizes should be found in every well-regulated pharmacy. These are made of brass, tinned iron, or enameled iron.

Indispensable in the prescription department are graduates or measures, from a pint down, made of glass, with the subdivisions of the unit marked on the sides (Fig. 19). The graduation of these measures is performed in two ways: in one the plunger used in making the utensils out of the molten glass is graduated; thus the finished graduate is produced in one operation. More popular, however, are those in which the graduating is done by hand, the quantity of liquid being poured into the ungraduated vessel from a burette, and this quantity of liquid is carefully marked, the finishing of the graduate being done by the engraver.

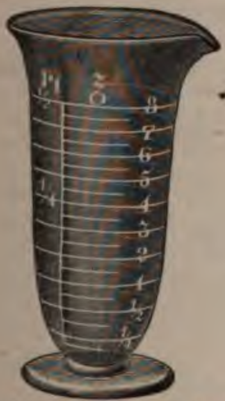


Fig. 19.—Eight-ounce graduate.

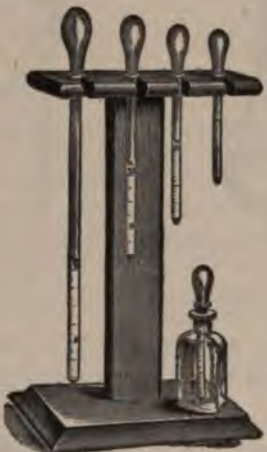


Fig. 20.—Squibb's minim pipettes.

The subdivisions of graduations are into drachms and minims in ordinary graduates, and into mils in the metric.

The minim graduate, however, is far from being reliable as a large amount of the liquid is retained by capillarity of the glass vessel, and, therefore, for measuring minute quantities, a pipette should be used. Such pipettes, graduated to minims, were put on the market by Dr. E. R. Squibb (Fig. 20), and are more reliable not merely by reason of the dispensing of the full quantity of the liquid, but, being narrower than a graduate of equal capacity, there is less chance for error in pouring more or less of the liquid into the utensil; the narrower the graduate, the more accurate can the quantity desired be determined.

In this way, for delicate analytic work, a liter graduate is rarely used, there being substituted for same a flask of such size that when filled with a liter of water the water rises within the narrow neck of the flask. Such liter flask is used chiefly in volumetric analysis, liquids being delivered

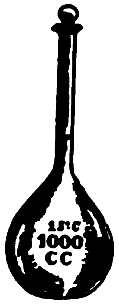


Fig. 21.—Liter flask.

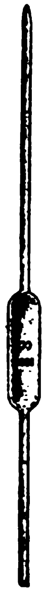


Fig. 22.—Volumetric pipette.

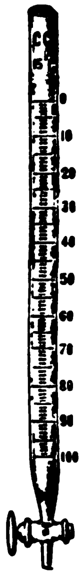


Fig. 23.—Burette

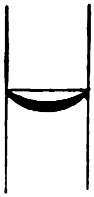


Fig. 24.—Meniscus (Sollmann).

and measured from same by means of pipettes (Fig. 22) and by burettes (Fig. 23).

In both cases the liquid is measured within a narrow tube, hence based on the same principle as the liter bottle (Fig. 21).

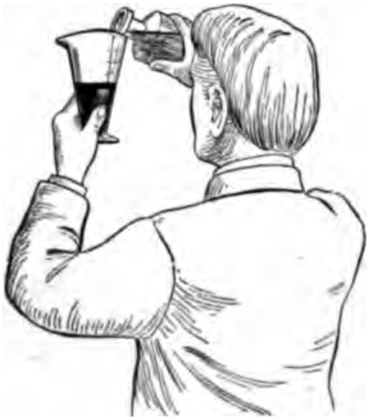


Fig. 25.—Pouring into graduate.

In placing liquids in a comparatively small utensil, like a burette, it will be observed that, through capillarity, the liquid is attracted to the sides of the vessel, thus making an edge which it is sometimes difficult to read; such an edge is called a "meniscus," and in reading the quantity of the liquid, the line representing the quantity should be exactly in the center of the meniscus (Fig. 24).

It is hardly necessary to state that in measuring liquids in a graduate the latter should be held perfectly level and the line representing the desired quantity even with the eye (Fig. 25).

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CHAPTER III

SPECIFIC GRAVITY

In Chapter II care was taken to mention that 454.6 grains was the weight of a fluidounce of distilled water. Why distilled water? Would it not be the weight of a fluidounce of chloroform as well? Common sense teaches that "some liquids are heavier than others," as we put it —that chloroform is heavier than water. A fluidounce of chloroform weighs about 670 grains, against 454.6 grains, the weight of the same volume of water. Accordingly, we see that chloroform is nearly one and one-half times heavier than water. That gives the idea of specific gravity, the definition of which can be given as *the relative weight of equal bulks of different bodies*, adding thereto the provision that, for solids and liquids, the unit of specific gravity is distilled water.

Now, to go back to our chloroform example: the volume, the bulk, the capacity of that one-ounce graduate remains the same whether it contains water or chloroform. Therefore a fluidounce—be it of water or of chloroform—represents "equal bulk." The respective weights of a fluidounce of the two liquids is "relative weight," and, reducing to unity, the specific gravity is obtained.

Instead of the term specific gravity, the word "density" is the more happy choice, since the term "specific gravity" suggests the gravitating force of the earth, which has only indirect connection with the subject.

The estimation of the specific gravity of various substances is of value, first, as the indication of purity or strength of the substance, and, second, through the data thus afforded we can estimate the volume of the substance, while in a minor degree it is sometimes of service in the diagnosis of disease.

The first application of density given above can be best explained by a simple illustration, thus: The average 93 per cent. sulphuric acid has a specific gravity of 1.83; in other words, is 1.83 times heavier than water. If this acid is mixed with water, the density of the liquid will vary to somewhere between 1.83 and 1.000, and, indeed varies, in proportion to the amount of water added.

In the same way official 92.3 per cent. alcohol has a specific gravity of

0.810, and is, therefore, 0.8 times as heavy as water. If such alcohol be mixed with water, the specific gravity of the liquid will rise to some point between 0.81 and 1.000, and, indeed, in proportion to the amount of water added; hence by taking the specific gravity of such liquid, we can estimate the exact strength of the liquid. Tables of this character have been carefully worked out, and are found in the pharmacopœia.

The other two uses of specific gravity being of minor importance, will be discussed in the appropriate place.

Estimation of the density of a body differs according as the substance is solid or liquid, and since, by the explanation given above, the specific gravity of liquids becomes simple, we will first discuss the estimation of the specific gravity of liquids; afterward, that of solids.

There are several ways of estimation of the specific gravity of liquids: (*a*) By use of pyknometer or specific gravity bottle; (*b*) with the hydrometer; (*c*) with the Mohr-Westphal balance; (*d*) with Lovi's beads; (*e*) with the Jolly spiral balance.

ESTIMATION OF SPECIFIC GRAVITY OF LIQUIDS

With the Pyknometer.—As mentioned above, the estimation of the specific gravity of a liquid is rendered simple because of the ease with which the weight of a bulk of given liquid can be compared to the weight of an equal bulk of water. Thus, in the simplest methods of estimation all that is necessary is to estimate the weight of a fluidounce of water in a graduate, then pour out the water, dry the graduate, pouring in the same measure of the liquid, the specific gravity of which is desired, weighing same, and then comparing the weight of the fluidounce of water with the weight of the fluidounce of liquid. As many times heavier as is the weight of the fluidounce of the liquid than the weight of the fluidounce of water, so many times heavier is that liquid than water, which figure represents the specific gravity. The inaccuracies of this method of estimation are due to the same causes as any inaccuracy in the measurement of liquids by means of the graduate, as mentioned in the preceding chapter, viz., the uncertainty in reading an exact volume of a liquid when placed in as wide a vessel as a graduate; hence, in order to obtain accurate results, we generally weigh the liquid, the weight of which is to be compared to the weight of an equal bulk of water, in a flask called a *pyknometer*, two modifications of which are shown in Figs. 26 and 27.

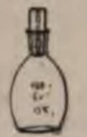

Fig. 26.—Pyknometer.

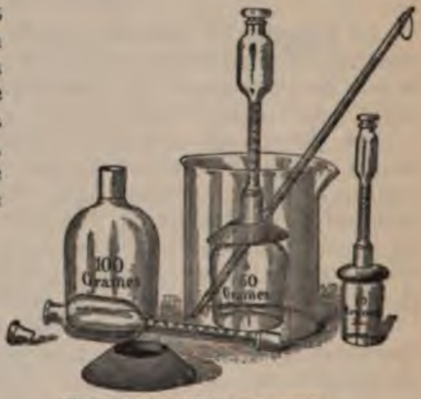

Fig. 27.—Squibb's pyknometer.

The only advantage a pyknometer (or specific gravity bottle) has over the graduate method just given is its greater accuracy. By tilting a graduate in measuring it is very easy to get a little more or a little less than the quantity desired, and every grain counts in estimating specific gravity.

In glancing at the narrow neck of the pyknometer it can be seen how the danger of incorrect readings is lessened. Then, too, the pyknometers usually hold 1000 grains or 100 grammes, which renders long division unnecessary. If a 1000-grain bottle holds 1500 grains of a certain liquid, it is obvious that the specific gravity of that liquid is 1.50.

In both cases the possible variation in the volume of the liquid when manipulated by a person of ordinary intelligence is practically nil.

The method of estimating specific gravity by means of the pyknometer is by all odds the most accurate means at our disposal, but the process is one requiring considerable time. To facilitate more rapid reading other instruments have been devised, most useful of which is the *hydrometer*.

The Hydrometer.—As to the principle of a hydrometer, if asked in which fluid one could float better, in fresh or in salt water, the instant answer would be in salt water. Why? Simply because salt water, being heavier, buoys one up more. And, following the rule, the heavier the liquid, the more it will buoy a body up, and, indeed, proportionally. To prove this may be cited that while a piece of iron will sink in water, on mercury it will float around like a chip in water. Why? Simply because while iron is eight times heavier than water, mercury is thirteen times heavier, and the lighter iron will float on the heavier mercury.

The hydrometer consists of a glass tube at the base of which two bulbs are blown, one containing enough shot or mercury to enable it to obtain an upright position when immersed in water, and the other and upper one filled with air (Fig. 28). According to the theorem of Archimedes, a body when immersed in water loses as much weight as the weight of the water it displaces, that is, a body displaces its own weight of a liquid and, accordingly, as the liquid is lighter or heavier than water, so does the hydrometer sink or rise when immersed in same.

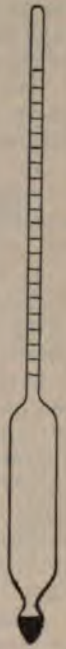

Fig. 28.—Hydrometer (schematic).

There are two classes of hydrometers, in one of which the weight of the hydrometer remains the same, whereas the point at which it floats varies accordingly as the liquid is lighter or heavier, and the other form, which is designed to float always at the same point in a liquid, which feat is accomplished by weighting down the hydrometer when immersed in a heavy liquid, *i.e.*, by meeting the buoyancy of the heavy liquid by adding weights in a pan at the top of a floating instrument.

Of the first class, we have such well-known hydrometers as Baumé's and Daniel's, while on the principle of the second type are based the Nicholson, Fahrenheit, and the Mohr specific gravity balance.

Baumé's Hydrometer.—The sketch and explanation on preceding page explain the construction of the above-named hydrometer, except details as to its graduation.

In constructing the hydrometer, it was early noted that such an instrument designed to measure accurately the specific gravity of the commonly known liquids, ranging, say, from ether (0.713) to bromine (3.000), would of necessity be so long as to be inconvenient.

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Baumé, at the outset, made two forms of this hydrometer, one for liquids heavier than water, and one for liquids lighter than water. The one for heavier liquids is graduated by weighting same with sufficient shot so that it would be almost completely immersed in water, and the point which was in contact with the surface of the water was marked or denominated zero. He then immersed this instrument in a 15 per cent. solution of common salt, whereupon, by reason of the superior buoyant force of this liquid over water, the hydrometer was pushed up and the point of contact of the hydrometer with the surface of the salt solution was marked off and denominated 15, and the space between the zero mark and 15 accurately divided into 15 spaces (provided always that the circumference of the tube was the same all along its length).

The remainder of the tube was divided into spaces equal to the 15 spaces between the water contact and the solution of salt contact, and this marking was arbitrarily denominated "degrees Baumé heavy."

In a similar manner was the hydrometer for lighter liquids constructed, this hydrometer being weighted so as to float in a 10 per cent. solution of salt at a point very near the base of the tube, and this point was marked zero.

It was then floated in water, when it naturally sank, and the place of contact with the surface of the water was marked 10, and the spaces between the water contact and the salt contact divided into 10 equal spaces, which spacing was continued up to the length of the tube, and in turn designated "degrees Baumé light." Thus were the original Baumé hydrometers constructed, but at present they are standardized by dipping the hydrometer in water and then into a standard liquid (concentrated sulphuric acid for the "heavy" hydrometer; ether for the "light" one), marking the floating point, the "degree Baumé" corresponding to the specific gravity of the standard liquid, and then subdividing the space between the floating point in water and in the standard liquid into the number of uniform spaces equal to the difference in "degrees" between water and the standard liquid.

This description shows how exceedingly arbitrary and confusing was the Baumé marking, for not only have we "degrees" which in themselves signify nothing, but we have "degrees Baumé light" and "degrees Baumé heavy." Thus, when the statement is made that the specific gravity of the liquid is 15° Baumé, the first thing that we must find out is whether a light or a heavy hydrometer was used, and, what is more unfortunate concerning this Baumé marking, is the fact that it is practically universally used in commerce where heavy chemicals are bought and sold by degrees Baumé rather than by their actual specific gravity.

It therefore behooves every retail pharmacist to be able to convert degrees Baumé into specific gravity rapidly, which can be easily done by using the following factors:

To convert heavy degrees Baumé into specific gravity:

$$\frac{145}{145 - {}^\circ\text{B.}} = \text{sp. gr.}$$

Thus 20° Baumé heavy =

$$\frac{145}{145 - 20} \text{ or } \frac{145}{125} \text{ or } 1.16$$

To convert light degrees Baumé into specific gravity, use the following factors:

$$\frac{140}{130 + {}^\circ\text{B.}} = \text{sp. gr.}$$

Thus 20° Baumé light =

$$\frac{140}{130 + 20} = \frac{140}{150} = 0.933.$$

Aside from these general features of the hydrometer we find modifications of the hydrometer especially adapted for taking the specific gravity of certain liquids; thus we have the *alcoholometer* for estimating the strength of alcohol through the specific gravity. Usually, the marking of this form of hydrometer is not in terms of specific gravity, but in the actual percentage of alcohol. In the same way we have the *lactometer* for estimating the strength and density of milk; the *saccharimeter* for estimating density of syrups; and the *urinometer* for estimating the density of urine.

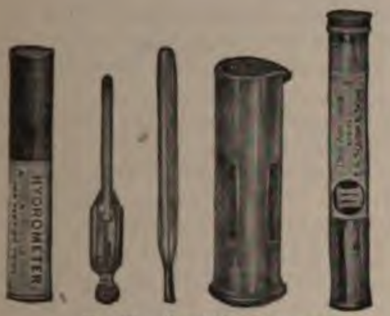


Fig. 29.—Squibb's urinometer.

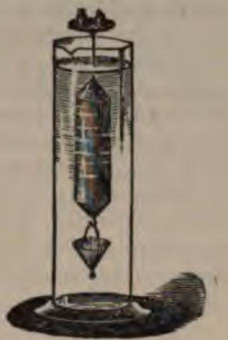


Fig. 30.—Nicholson's hydrometer.

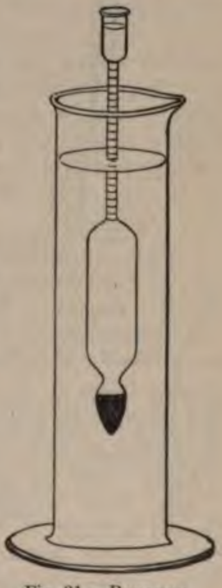


Fig. 31.—Rousseau densimeter.

Urine differs in specific gravity from 1.010 to 1.070, and since the instrument is very small, the marking is from 10 to 70 instead of the actual specific gravity, as stated above.

The best form of urinometer shown in Fig. 29 was devised by Dr. E. R. Squibb.

Nicholson's Hydrometer.—This apparatus is of scientific interest because its principle of action differs from that of the hydrometers just considered by being arranged to operate at a constant level, but with varying weight. Such a hydrometer has but one mark on tube, and is made to float in all liquids at this point by adding or taking away weights from the pan, as shown in Fig. 30.

On account of the inconvenience of using it, this hydrometer is practically limited to lecture counter demonstration, though at least two modifications of same principle are found in very useful forms of specific gravity apparatus.

The first of these is *Rousseau's densimeter*, shown in Fig. 31, in which the scale pan of the Nicholson hydrometer is replaced by a small cup, and into this cup is poured the liquid the specific gravity of which is desired, while the instrument itself is floated in water. From the depth to which the standard amount of liquid sinks the hydrometer, the specific gravity of the liquid can be deduced. The prime value of Rousseau's densimeter is to take the specific gravity of liquids which are either very costly or so rare that a larger quantity, such as is necessary for a pyknometer or a hydrometer, is not obtainable.

The Mohr-Westphal Balance.—In this balance, as in the Nicholson hydrometer, the specific gravity is estimated by the floating of a weighted cylinder which is kept at a constant level by means of applying weights. The balance as shown (Fig. 32) is far more convenient to handle than the Nicholson, inasmuch as the floating cylinder is permanently attached to the end of the scale beam, and a constant level maintained by keeping the balance in equilibrium. In making such a balance a cylinder is made out of small glass tube weighted with an appropriate quantity of mercury, (or else a thermometer) and the exact bulk of same is carefully estimated by immersing same in water contained in a burette or other narrow graduated tube, and noting the rise of the water when the cylinder or thermometer is completely immersed.

This cylinder is suspended from one end of the beam, the other end of which is weighted so as to produce equilibrium in air. When the cylinder is immersed in water, the buoyancy of the latter throws the balance out of equilibrium, which, however, can be restored by placing on the beam, directly over the knife-edge from which the cylinder is suspended, an appropriate weight in the form of a rider; this weight must, of course, be exactly that of the weight of the bulk of water, equal to the bulk of the cylinder, for the body immersed in water loses as much weight as the weight of the water displaced.

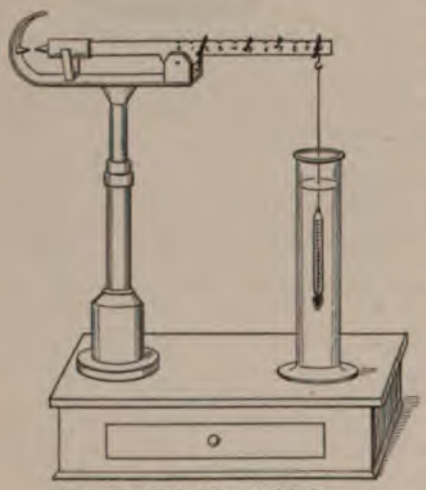


Fig. 32.—Mohr-Westphal balance.

In the Westphal balance the beam is accurately divided into ten equal parts, up and down which the rider can be freely moved. Duplicate of this rider weight is also provided, and likewise two weights, one-tenth and one one-hundredth the value of the original rider weight. By means of these rider weights the specific gravity of any liquid can be accurately determined. Thus, in the picture one large rider is on the notch over the point of suspension, meaning specific gravity 1.000. The second large rider is on the notch 2 of the beam, corresponding to specific gravity 0.200. The one-tenth weight rider is on notch 5, corresponding to specific gravity 0.05; while the one one-hundredth weight rider is on notch 7, corresponding to specific gravity 0.007. These four weights, therefore, show that the specific gravity of the liquid is 1.257.

Lovi's Beads.—Lovi's beads are one of the simplest forms of hydrometers. They consist of beads of glass so weighted with mercury that a definite proportion exists between the weight of the bead and its volume. Thus, a bead measuring 2 mils, if weighted with mercury enough to weigh exactly 3 Gm., will be one and one-half times heavier than water, since 2 mils of water weighs 2 Gm.

A bead having the capacity of 2 mils and weighing 2½ Gm. would be one and one-fourth times heavier than water. A bead having a capacity of 2 mils and containing enough mercury to weigh 1½ Gm. would be three-fourths as heavy as water, or have a specific gravity of 0.75, and, lastly, a bead of 2 mils, containing enough mercury to weigh exactly 2 Gm., would be the same weight as water, or specific gravity 1.000.

After getting their weights accurately adjusted, the beads are sealed and the specific gravities marked on the outside thereof.

If these four beads were thrown into water, the one having specific gravity 0.75, being lighter than the water, would float therein, and the ones of the specific gravities 1.50 and 1.25 would sink, being heavier than the water, while the one of exactly the same specific gravity as the water would float indifferently at any place in the water where immersed. In the same way, if these beads were thrown into a liquid of specific gravity 1.25, the bead marked 1.50 would sink, those of specific gravities 0.75 and 1.00 would float on the surface of the liquid, while the one of specific gravity 1.25 would float indifferently.

Thus are Lovi's beads employed, a handful of them being thrown into the liquid the specific gravity of which is to be ascertained, and the one which floats indifferently in the solution is of necessity of the same specific gravity as the liquid.

The application of such beads is usually limited to the estimation of specific gravity of boiling liquids, in some processes of manufacture it being directed that the liquid be evaporated to a certain specific gravity. If in such a heated liquid a hydrometer is placed, there is more danger of fracture than if Lovi's beads were applied.

Jolly's Spiral Balance.—This balance, described on p. 29, can be used instead of the ordinary balance for estimating specific gravity of either solids or liquids. In the case of solids, the weight of same is ascertained in air and then in water and the well-known rule applied: weight in air divided by loss of weight in water equals specific gravity.

In case of estimating specific gravity of liquids, a sinker whose volume is known is suspended from the balance, and its downward force, its weight, is estimated in air, in water, and in the liquid whose specific gravity is desired to be known. In this way we learn the loss of weight of the sinker in water and in the liquid, and from these data the specific gravity of the liquid in question is deduced.

ESTIMATION OF SPECIFIC GRAVITY OF SOLIDS

The specific gravity of solids can be estimated in several ways: (*a*) By means of graduated tube; (*b*) by floating in liquid of known specific gravity; (*c*) by means of a hydrostatic balance; (*d*) with a pyknometer.

With Graduated Tube.—Specific gravity is the weight of a substance compared to the weight of an equal bulk of water, and, as cited above, the estimation of the weight of a certain bulk of liquid and comparison of this to the weight of an equal bulk of water means the simple expedient of weighing a certain volume of the liquid and comparing it to the weight of the same volume of water. Taking the specific gravity of a solid is rendered more difficult by reason of the fact that the great majority of masses of solids possess irregular surfaces, making the exact measurement of their cubical capacity an impossible task, while the lack of mobility of their particles, which distinguishes the solid from the liquid, prevents solid masses from assuming the shape of a standard vessel. Hence the weighing of a certain bulk of solid, for comparison with an equal bulk of water, by means of a pyknometer alone, is out of the question. The only method, therefore, of estimating the volume of the substance as compared to the volume of water is by immersing the solid in the water contained in a graduate tube and noting the rise of the water upon immersion. Thus, if a piece of brass weighing eight grammes immersed in water contained in a burette causes the surfaces of that water to rise one mil, it will mean that one mil of this brass weighs eight grammes. We know that one mil of water weighs one gramme, and if the brass weighs eight times as much as the water, its specific gravity is, therefore, eight.

By Immersing Solid in Liquid of Known Specific Gravity.—We have already learned, under Lovi's beads, that a substance weighing the same as the same bulk of a certain fluid will float indifferently in that fluid, and this principle was used to estimate the specific gravity of a liquid by throwing beads of known specific gravity therein. Inversely, the specific gravity of a solid can be estimated by throwing the solid into liquids of different specific gravities, and noting in which liquid the substance floats, in which it sinks, and, above all, in which it floats indifferently. Thus, if a piece of ore sinks in a solution of mercuric nitrate of specific gravity 2.00 and floats in a solution of potassiomercuric iodide of specific gravity 3.00, it can be safely assumed that this ore has a specific gravity somewhere between these two figures, and the exact specific gravity can be ascertained by diluting the last solution with sufficient water until the ore floats indifferently therein, then noting the specific gravity of the liquid by means of the hydrometer.

Such method of estimation is of comparatively limited application, by reason of its lack of convenience, and an accurate estimation by this method takes more time than does the well-known process of weighing in air and then in water. Its chief use, therefore, is limited to mineralogic work, in which case a series of solutions of known specific gravities, ranging from 1½ to 3, are kept constantly on hand, and the estimation of the selected ore made by throwing same into one solution, then into another, until we find the solution in which it floats indifferently.

A pharmaceutic application of this method was suggested by Hager for estimating the specific gravity of wax, he preparing a series of ten strengths of diluted alcohol of specific gravities ranging from 0.950 to 0.970, and the freshly melted drop of wax is thrown into one after the other of these solutions. A modification of this method is used for wax in the present Pharmacopœia.

The two methods of estimation of specific gravity just given are of little pharmaceutic value, and are cited first merely because they give the principles of density more clearly than the method in general use; that estimation being—

By Means of a Hydrostatic Balance.—In taking the specific gravity of solids by this process four conditions are possible:

First, the solid may be insoluble in, and heavier than, water.

Second, the solid may be insoluble in, and lighter than, water.

Third, the solid may be soluble in, and heavier than, water.

Fourth, the solid may be soluble in, and lighter than, water.

(A) *Solids Insoluble in and Heavier than Water.*—As mentioned above, the direct comparison of the bulk of a mass of solid with the same bulk of water is a matter of some difficulty. Some indirect method had to be devised, and this was reached by a practical application of a theorem of Archimedes, one of the ancient philosophers.

Suppose, into a glass full of water to the brim, an eight-ounce brass weight is dropped; of course, the water will overflow. Now, Archimedes found an interesting comparison between the weight of the overflowing water and the changed weight of the brass in the water. He found that a body in water weighed less than it did in air. The student should demonstrate this for himself, for practical demonstrations are of great value. Take a hand scale and tie a weight beneath the pan; weigh it in the air, then in the water, when it will be found that brass, which weighs eight ounces in air, weighs only seven ounces in water. It, therefore, loses one ounce of its weight when immersed in water.

Archimedes showed that the amount of water displaced from the full glass mentioned above was one ounce in weight also. Accordingly, he devised his famous theorem, "A body immersed in water loses as much weight as the weight of the water it displaces." Naturally, the amount of water displaced by a body means a bulk equal to that body, and thus we indirectly get the weights of equal bulks of water and the body with which we are experimenting. If the relative weights of equal bulks of water and some other liquid were as 1 is to 8, the specific gravity of the other liquid would be 8 divided by 1, or 8; if the relative weights were, say, 240 grains for water and 480 grains for the other liquid, the specific gravity of the latter would be 480 divided by 240, or 2. Remember that loss of weight of a body in water means the weight of a bulk of water equal to that of the body, and one can easily understand the rule for taking the specific gravity of solids. "Weigh the body in air, then in water. Divide the weight in air by the loss of weight in water, and the quotient will be the specific gravity."

The principle of this case has been considered, but as to practical manipulation, it need only be stated that the substance of which the specific gravity is desired is attached to a balance by a fine silk thread, better, a horsehair, suspended in a beaker, or other suitable glass containing distilled water of definite temperature (usually 15°C.), after being carefully weighed in air.

It will be observed that the body weighs less in water than it did in air, and the difference between these two figures (the loss of weight in water) is, according to the theorem of Archimedes, exactly the same as the weight of the same bulk of water; hence if an 8-gramme brass weight immersed in water weighs 7 grammes, the loss of weight of one gramme can be transcribed into the statement that the quantity of water of exactly the same bulk as the 8-gramme weight would weigh exactly 1 gramme.

If, during this experiment, the brass weight is immersed in a graduated tube, it will be found that, on placing the 8-gramme brass weight below the surface of the water, the water in the tube will rise exactly one mil if the temperature of the water is 4°C. Now, one mil of water weighs one gramme, and, therefore, we learn that the loss in weight in water of a given substance is exactly equal to the weight of an equal bulk of water.

This being the case, we see that, by estimating the loss of weight in water, we have a direct comparison of the weight of the substance with the weight of an equal bulk of water, and all that is necessary in order to deduce the specific gravity is to divide the weight in air by the loss of weight in water, that is, divide the weight in air by the weight of an equal bulk of water, it being always remembered that the specific gravity means how many times heavier is a substance than is the same bulk of water. Hence, memorize this rule: *Weight in air, divided by loss of weight in water, equals specific gravity.*

(B) *Solids Insoluble and Lighter than Water.*—Such solid of necessity floats on the surface of the water, and in order to find the loss of weight in water the substance must be completely immersed. In estimating the specific gravity of such solids they must be forced under the surface of the water by attaching some heavy substance, for example, a brass weight.

The method of taking the specific gravity of the substance after immersion is practically the same as that of taking the specific gravity of a solid insoluble in and heavier than water, namely: we must know the weight of the substance and the sinker separately in air, the weight of both in water, and the weight of the sinker alone in water.

The weight of the two substances, minus the weight of both in water, gives the loss of both in water, and from this figure the loss of the weight of the sinker alone is taken; we then have the loss of weight of the lighter substance in water, whereupon we apply the rule: *Weight in air divided by loss of weight in water equals specific gravity.*

An illustration of such an estimation is as follows: A piece of wax weighs 4 grammes in air, and to immerse same, we attach a brass weight weighing 50 grammes. The two weigh in water 43.84 grammes; hence the loss of the weight of the two in water equals 54—43.84, or 10.16 grammes.

Then we immerse the sinker in water and find it weighs 44 grammes. Then the weight of the sinker in air (50 grammes), minus the weight of the sinker in water (44 grammes), equals the loss of weight of the sinker in water (6 grammes). The combined loss of weight (10.16 grammes) minus the loss of the sinker alone (6 grammes) gives the loss of the weight of wax in water (4.16 grammes). The weight of the wax in air (4 grammes), divided by the loss of the weight in water (4.16 grammes), gives the specific gravity (0.960).

In observing these figures, the student is confronted with what, at a first glance, seems a peculiar statement, that a piece of wax weighing 4 grammes loses, when immersed in water, 4.16 grammes; that is, it loses more weight than it actually possessed. This can be easily explained, however, when we appreciate the fact that weight is merely the measure of the gravitating force of the earth, and that when a substance hanging toward the earth is immersed in a liquid, it is acted upon by an opposing upward force, namely, the buoyant force of water. This explains why, when a substance is immersed in water, it is said to lose weight, the so-called loss of weight being the difference between the actual attractive force of the earth and that same force when modified by the upward force of the liquid in which the substance is immersed.

In case of solids lighter than water the upward buoyant force of the liquid is greater than the downward force of gravitation, hence the phenomenon of a body losing more weight than it originally possessed.

(C) *Solids Soluble in and Heavier than Water.*—It is hardly necessary to state that with some substances (lump-sugar, for example) we cannot accurately estimate the loss of the weight in water, for while we are endeavoring to weigh the substance in water, the water will be dissolving the solid, which will finally disappear under the solvent action of the liquid; in such cases, therefore, we must have recourse to an indirect estimation, namely: by estimating the loss of weight of the substance in some liquid in which it is insoluble, and, from this, estimating what would be the loss of weight of the same substance in water by a proportion involving the respective specific gravities of the two liquids.

Thus, if a piece of alum weighs in air 3 grammes, and weighs in turpentine (sp. gr. 0.87) 1.48 grammes, the loss of weight in turpentine will be 1.52 grammes. If we divide the weight in air by the loss of weight in turpentine, we would estimate how many times heavier the substance was than turpentine, which datum is of no interest to the observer. In other words, the loss of weight in turpentine represents the weight of an equal bulk of turpentine, while what we really want to know is the weight of an equal bulk of water (or loss of weight in water).

This is estimated by the following proportion:

The specific gravity of turpentine is to specific gravity of water as the loss of weight in turpentine is to the loss of weight in water, and applying this to the above example, we have:

$$0.87 : 1.00 :: 1.52 : \times$$

$$\times = \frac{1.00 \times 1.52}{0.87} = 1.74.$$

By this we see that the piece of alum, which lost 1.52 grammes in turpentine, would lose 1.74 grammes if it were possible to estimate the loss of weight in water by immersing same therein. This obtained, we apply the usual rule:

Weight in air divided by loss of weight in water equals specific gravity, and get—3.00 ÷ 1.74 = 1.73. (Specific gravity of the alum.)

(D) *Solids Soluble in and Lighter than Water.*—Of this comparatively rare class of bodies it need only be said that the estimation of the specific gravity of same is carried on by combining the two previous methods of estimation, viz., to the substance we attach a weight or sinker and immerse same in some liquid in which it is insoluble; in this way we have a double estimation to perform: First, to subtract the loss of weight of the sinker from the combined loss of weight, as in B. Take the loss of weight of the substance alone in the liquid, and deduce therefrom the loss of weight in water, as in C. Lastly, apply the rule: *Weight in air divided by loss of weight in water equals specific gravity.*

With the Pyknometer.—The estimation of specific gravity of solids by means of the balance is limited to such substances possessing sufficient cohesion to enable same to be suspended from a thread or horsehair, a method which is inapplicable to powders.

In estimating the specific gravity of powders, therefore, recourse is had to a modification of the pyknometer experiment, which can be best explained by citing a possible case.

Assuming we had powdered calomel weighing 10 grammes, we would take the specific gravity of same in a pyknometer, holding, say, 100 grammes distilled water. Now, if all the 100 grammes of water would remain in the pyknometer on the addition of calomel, the combined weight would be, of course, 110 grammes. However, it is an accepted fact that when the powdered calomel is placed in a bottle, water will be displaced and some rejected, the amount of rejected water being equal to the weight of an equal bulk of calomel. In the actual experiment the weight of the 10 grammes of calomel and of water sufficient to fill the 100-gramme bottle was found to be 108.6 grammes. This shows that the amount of water displaced is 110–108.6, or 1.4 grammes. In other words, the weight of a bulk of water equal to the bulk of the 10 grammes calomel was 1.4 grammes; hence the calomel is as many times as heavy as water as 1.4 goes into 10; hence the specific gravity of the calomel is 10 ÷ 1.4, or 7.1.

As mentioned on p. 47, the knowledge of the specific gravity of pharmaceutic substances aids us in estimating the volume of a certain weight of liquid.

Thus, if we know that the specific gravity of sulphuric acid is 1.83, and we have a recipe calling for a given weight of same, we can transcribe this weight into the liquid volume of the acid by dividing the number of grammes directed by the specific gravity of the acid. In the same way if we wish to know what size container is necessary to hold twenty avoirdupois pounds of glycerin (sp. gr. 1.25), we can find out by a simple calculation involving the number of gallons in twenty pounds of water and dividing this number by the specific gravity of glycerin. This latter example, however, is perhaps more properly solved by specific volume, mention of which will be made shortly.

In answer to the question as to the pharmaceuticals of which we should study the specific gravities, it might be stated that every pharmacist should know at least the following:

Ether	0.716
Chloroform	1.475
Glycerin	1.249
Alcohol	0.810
Sulphuric acid	1.83
Nitric acid	1.403
Mercury	13.5

These figures represent the specific gravity of each substance at 25°C. (77°F.), for bear in mind that temperature is an important factor in deducing specific gravity—the warmer the temperature, the less dense the liquid.

A practical demonstration of the use of specific gravity may be valuable. We want to know how many grains there are in a fluidounce of ether, specific gravity 0.720.

One fluidounce of distilled water weighs 454.6 grains; therefore a fluidounce of ether, sp. gr. 0.716 weighs 454.6 × 0.716 = 325.49.

$$\begin{array}{r} 454.6 \\ 0.716 \\ \hline 27276 \\ 4546 \\ 31822 \\ \hline 325.4963 \end{array}$$

SPECIFIC VOLUME

Specific volume is just the reverse of specific gravity.

Specific gravity is the relative weight of equal bulks of different bodies.

Specific volume is the relative bulk of equal weights of different bodies.

To get the specific volume of a body we divide 1.000 by the specific gravity. Thus, the specific volume of chloroform is approximately 0.666+

$$1.000 \div 1.50 = 0.666+.$$

As a homely example, while specific gravity means, in a general way, how many avoirdupois ounces, grammes, etc., in one pint, liter, etc., of alcohol, chloroform, etc., specific volume teaches what size bottle it will take to hold a pound or a kilogramme of the substance in question. Thus specific gravity deals with what weight of a certain substance will go into a certain sized bottle, while specific volume asks what sized bottle will hold a certain weight of the substance. If we say chloroform has the specific gravity 1.50, we mean (since pint and avoirdupois pound of water are somewhat approximate) that a pint of chloroform weighs somewhere around 1½ avoirdupois pounds. Regarding this same chloroform, an avoirdupois pound of it will not, as is full well known, fill a pint bottle. In fact, it will easily go into a twelve-fluidounce bottle. We get nearer its exact bulk by dividing 16 by the specific gravity, or, in the present case, 16 divided by 1.50 equals 10.6, and we find that one avoirdupois pound of chloroform has a bulk of about 10.6 fluidounces. This is only approximate, for, in truth, a pint of water weighs more than an avoirdupois pound, and, again, the specific gravity of chloroform is 1.475 (at 25°C.), not 1.50. The exact estimation of the weight of a pint and the volume of an avoirdupois pound of chloroform is as follows:

1 pint = 16 fluidounces.
1 fluidounce distilled water = 454.6 grains.
1 pin. (16) fluidounces distilled water = 454.6 grains × 16 = 7273.6 grains.
16 fluidounces chloroform (sp. gr. 1.475) = 7273.6 × 1.475 = 10,728.56 grains.
7000 grains = 1 avoirdupois pound.

Therefore, in 10,728.56 grains there are as many avoirdupois pounds as 7000 goes into 10,728.56:

10,728.56 divided by 7000 = 1.532,

and we see that one pint of chloroform weights 1.532 avoirdupois pounds, considerably over 1½ avoirdupois pounds. Now for the volume of one avoirdupois pound of chloroform:

1.534 avoirdupois pounds of chloroform measure 16 fluidounces.
1 avoirdupois pound of chloroform will measure $^{1000}/_{1532} \times 16 = 10.4$ ounces—

$$\begin{array}{l} 1532)16000(10.4+ \\ \underline{1532} \\ 6800 \\ \underline{6128} \\ 144 \end{array}$$

Before closing this chapter, other phases of simple arithmetic as applied in pharmacy may well be taken up.

ALLIGATION

Alligation, or "the rule of mixtures" as applied in pharmacy, includes those arithmetic processes used in ascertaining the relative amount of different strengths of the same substance needed to blend into a substance of a definite intermediate strength. Thus, by alligation we solve such problems as the blending of two strengths of opiums into a third strength.

Opium, as we will learn later, is a substance whose activity is based on the amount of morphine it contains, and when we say 10 per cent. opium, we mean that 100 grammes of the drug contain 10 grammes morphine; by 18 per cent. opium we mean one that contains 18 grammes morphine to each 100 grammes; while 14 per cent. opium is such as contains 14 grammes to the hundred. It can be seen that we can combine 10 per cent. opium and 18 per cent. opium to make 14 per cent. opium, nor is it difficult to figure out that equal quantities of 10 per cent. and 18 per cent. will make 14 per cent.; but upon what principle is the arithmetic calculation based?

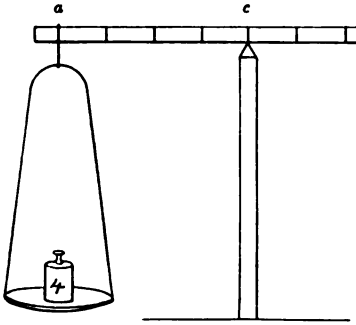
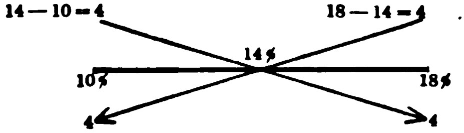


Fig. 33.—Alligation I.

The best comparison of alligation is with the principle of the balance, as fully explained on p. 36. What do we mean by a single equal arm balance? It means a beam represented by the line *a–b* (Fig. 33) of the same weight throughout, suspended on a central knife-edge, with pans hanging from the end knife-edges (*a* and *b* respectively). In order that the balance swing exactly even it is necessary that the central knife-edge, *c*, be exactly midway between *a* and *b*. Thus, if we call *a* 10 inches, and *b*

18 inches, the beam would be 18 − 10, or 8 inches long, and if *c* be at 14 inches, it will stand 18 − 14, or 4 inches, from *b*, and 14 − 10, or 4 inches, from *a*, and 4 pounds placed on pan *a* would be exactly balanced by 4 pounds placed on pan *b*.

Compare this to the following opium alligation. We have 10 and 18 per cent. opiums and wish to mix them so as to make 14 per cent. This we solve as follows:



And we see that 4 pounds of 10 per cent. and 4 pounds of 18 per cent. give 8 pounds of 14 per cent.

Again, what do we mean by a single beam unequal arm balance? We mean a beam, like Fig. 33, only with knife-edge *c* *not* midway between *a* and *b* (Fig. 34).

Assuming as before that we call *a* 10 inches and *b* 18 inches, we would have a beam 8 inches long, and if *c* were at 12 inches, it would stand 18 − 12, or 6 inches, from *b*, and 12 − 10, or 2 inches, from *a*. In order to balance such a beam different weights must be placed on pans *a* and *b*, following the general principles of the lever; namely, a certain weight placed on the pan of the long arm *b* will exert an increased power on the weight in the pan of the short arm *a*, and in direct proportion to the length of the arms. Thus, in Fig. 34 the long arm *b*–*c* (6 inches) is 3 times longer than the short arm *a*–*c* (2 inches); hence 1 pound placed on pan *b* will balance 3 pounds placed on pan *a*, or 2 pounds in pan *b* will balance 6 pounds in pan *a*. Compare this to the following opium alligation. We have 10 and 18 per cent. opiums and desire to mix them so as to make 12 per cent. This is solved as follows:

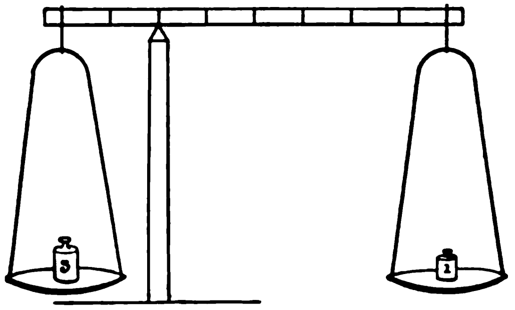
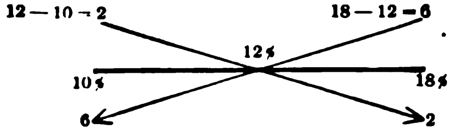


Fig. 34.—Alligation II.



And we see that 6 pounds of 10 per cent. and 2 pounds of 18 per cent. give 8 pounds of 12 per cent.

Likewise, assuming our beam has different dimensions, as follows: A, 9 inches; B, 14 inches; C, 12 inches. The beam will then be 14 – 9, or 5 inches long, and *c* being 12 – 9, or 3 inches from *a*, and 14 – 12, or 2 inches, from *b*, then the weight of 3 pounds placed on pan *b* (14 inches) will be balanced by 2 pounds placed on pan *a* (9 inches).

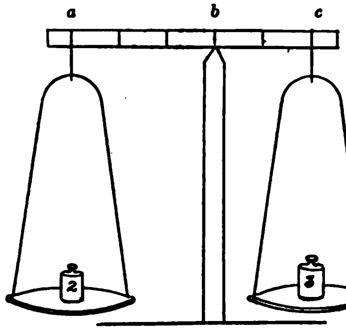
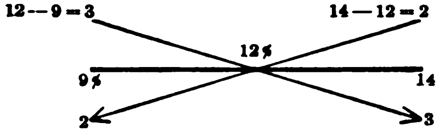


Fig. 35.—Alligation III.

Compare this to the following alligation:

We have 9 and 14 per cent. opiums and want to make 12 per cent. This we solve below:



And we see that 2 pounds 9 per cent. and 3 pounds 14 per cent. give 5 pounds 12 per cent.

Thus, can every problem in alligation be solved, and when we draw our line, with the percentage wanted, above, and the percentages we have, below, like this—

12
9 14

we are unconsciously comparing the matter to a single beam balance. A purely arithmetic solution of alligation is the following tiresome but lucid process.

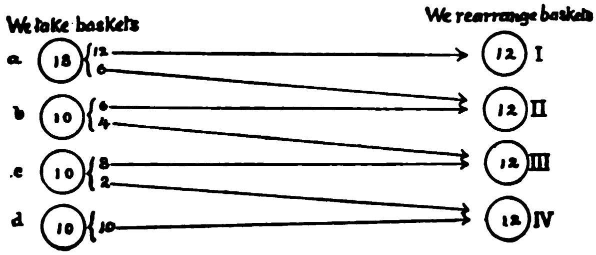
Suppose we take the problem given above: How much 10 and 18 per cent. opiums are needed to make 12 per cent.?

10 per cent. opium means 10 parts morphine to 100 parts opium.
18 " " " 18 " " 100 " "
12 " " " 12 " " 100 " "

These figures are exactly analogous to:

10 apples in a basket
18 " "
12 " "

and as if the question were, How many baskets of 10 apples each and 18 apples each must be taken to arrange baskets containing 12 apples each? Let us do the actual rearranging:



One basket of 18 apples. This gives us one basket of 12 apples (No. 1) and 6 apples over. These 6 and 6 from a basket of 10 apples, which we bring here, will make another basket of 12 apples (No. II). Six apples from 10 leaves 4 apples in our basket *b* and, bringing up basket *c* (10 apples) we take out 8, making basket No. III contain 12 apples. This leaves 2 apples in basket *c*, which, plus 10 apples from basket *d* makes 12 apples to put into basket IV, and the trick is done.

The conclusion is that 1 basket of 18 apples and 3 baskets of 10 apples each give 4 baskets of 12 apples each; the same result as the similar alligation, which showed that—

6 pounds of 10 per cent. (or 3 pounds of 10 per cent.).
and 2 pounds of 18 " (or 1 pound of 18 per cent.).
give 8 pounds of 12 " (or 4 pounds of 12 per cent).

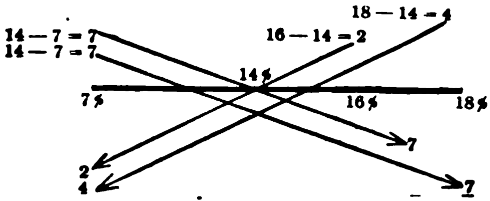
For the benefit of those knowing algebra the following algebraic solution of these kind of problems is given:

Let x represent quantity of the lowest percentage used.
Let y " " " highest percentage used.
Let z " " " percentage desired.

Then the problem, How much 10 and 18 per cent. opiums are needed to make 12 per cent.? is solved as follows:

$10\,x + 18\,y = 12\,z. \quad z = x + y.$
$10\,x + 18\,y = 12\,x + 12\,y.$
$18\,y - 12\,y = 12\,x - 10\,x.$
$6\,y = 2\,x. \quad x = 3\,y.$
Then, if $x + y = 4$ pounds, and $x = 3\,y$, $3\,y + y = 4$ pounds, or $4\,y = 4$ pounds
$x = 3\,y. \quad y = 1$ pound. $x = 3$ pounds.
Hence, 3 pounds 10 per cent.
and 1 pound 18 per cent.
give 4 pounds 12 per cent.

If the problem involves three different percentages, say, 7 per cent., 16 per cent., and 18 per cent., out of which to make another percentage, say, 14 per cent., the calculation is accomplished by means of the mechanic "rule of the balance" explained above, viz.,



That is: 6 ounces of 7 per cent. opium.
7 " 16 " "
7 " 18 " "
make 20 ounces of 14 per cent. opium.

And if the problem was, to make 14 per cent. opium from 5 per cent., 15 per cent., 16 per cent., and 18 per cent. opium, the calculation would be as follows:

14 − 5 = 9. This goes under 15 per cent., 16 per cent., and 18 per cent.
15 − 14 = 1. This goes under 5 per cent.
16 − 14 = 2. This goes under 5 per cent.
18 − 14 = 4. This goes under 5 per cent.

14 per cent.

5 per cent.	15 per cent.	16 per cent.	18 per cent.
1	9	9	9
2			
4			
7	9	9	9

That is: 7 ounces of 5 per cent. opium.
9 " 15 " "
9 " 16 " "
9 " 18 " "
make 34 ounces of 14 per cent.

In explanation of the fact that in the examples furnished above we find two, and in the other case three, separate quantities of lower percentage which must be added to the stronger, let it be said that the example can be considered as three separate examples or problems, viz.:

(A) How much 5 per cent. and 15 per cent. needed to make 14 per cent.?

Answer by simple calculation: 1 ounce of 5 per cent. and 9 ounces of 15 per cent.

(B) How much 5 per cent. and 16 per cent. needed to make 14 per cent.?

Answered by simple calculation: 2 ounces of 5 per cent. and 9 ounces of 16 per cent.

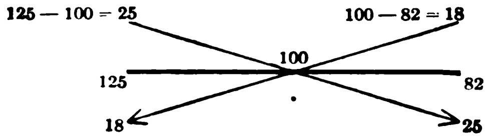
(C) How much 5 per cent. and 18 per cent. needed to make 14 per cent.?

Answered by simple calculation: 4 ounces of 5 per cent. and 9 ounces of 18 per cent.

We, therefore, have three separate batches of 14 per cent. opium, all made from 5 per cent., but with higher percentage differing in every case. If we took these three separate mixings and thoroughly blended same, we would, of necessity, have 14 per cent. opium, and this 14 per cent. opium would originally have been made up of—1 ounce 5 per cent. +9 ounces 15 per cent. +2 ounces 5 per cent. +9 ounces 16 per cent. +4 ounces 5 per cent. +9 ounces 18 per cent.; in all, 7 ounces 5 per cent., 9 ounces 15 per cent., 9 ounces 16 per cent., and 9 ounces 18 per cent., which we notice is the answer to the example as originally given.

The same method of calculation for alligation can be applied to specific gravity examples, such as: How much glycerin, specific gravity 1.25, and alcohol, specific gravity, 0.820, must be mixed to make a liquid of specific gravity 1.000? which is solved as follows:

1.00
1.25 0.82 or, preferably,



Answer: 18 ounces glycerin
and 25 ounces alcohol
make 43 ounces of liquid, sp. gr. 1.00.

This example and also the percentage examples can be proved by the following reasonings:

18 fluidounces glycerin sp. gr. 1.25 = 18 × 454.6 × 1.25 = 10228.5 grains.
25 fluidounces alcohol sp. gr. 0.82 = 25 × 454.6 × 0.82 = 9319.3 grains.
43 fluidounces of liquid weigh 19547.8 grains.
43 fluidounces of water weigh 43 × 454.6 = 19547.8 grains.

Hence the mixture has about the same specific gravity as water, since 43 fluidounces of it weigh the same as 43 fluidounces of water.

The same method is used to solve such examples as:

What will be the specific gravity of a mixture of 5 fluidounces of solution of tersulphate of iron, specific gravity 1.555, and 3 fluidounces water? The figuring being as follows:

5 fluidounces of sol. tersulph, iron = 5 × 454.6 × 1.555 = 3534.5 grains.
3 fluidounces of water = 3 × 454.6 × 1.000 = 1363.8 grains
8 fluidounces of liquid weigh 4898.3 grains.
8 fluidounces of water weigh 8 × 454.6 = 3636.8.

Hence the liquid weighs $4898.3/3636.8$ as much as water and has the specific gravity 1.346.

While speaking of such examples, reference should be made to the simple example involving percentage solutions, such as: How much cocaine is needed for one fluidounce of a 5 per cent. solution?

The absolutely accurate way of solving this is as follows:

$$\left.\begin{array}{c}\text{Weight fluidounces water}\\ \text{454.6 grains}\end{array}\right\} \times 0.05 = 22.73 \text{ grains,}$$

which represents the number of grains cocaine (hydrochloride presumably) needed to make the solution.

In this case, however, in order to obtain accurate results, the 22.73 grains cocaine hydrochloride, must be weighed out, dissolved in water, and finished by bringing the finished solution up to 454.6 grains by weight, which, of course, will measure slightly less than one fluidounce.

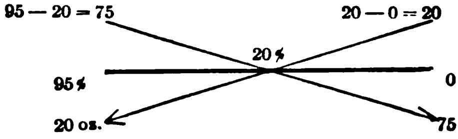
Another and less accurate method, very largely employed, is by taking 5 per cent. of 480 minims, or 24 grains, dissolving this in water to make a fluidounce. This, while by no means as accurate as the former process, is more convenient, and can be safely employed in preparing solutions in small percentages.

A simple modification of alligation is that of percentages outlined in the last pharmacopœia under alcohol, where a rule of dilution is given. The rule is practically as follows:

If we have a 95 per cent. alcohol and want to dilute it to 20 per cent., we must then take 20 fluidounces of the 95 per cent. and add enough water to make 95 fluidounces; when we will have approximately 20 per cent. alcohol.

It may also be solved by the regular process of alligation if we recast the problem to the following wording: How much 95 per cent. alcohol and 0° alcohol (water) needed to make 20 per cent. alcohol?

Solved by "rule of the balance."



This shows that we can reduce 95 per cent. alcohol to 20 per cent. by reversing the fluidounces with the percentages. That is, from 20 fluidounces of 95 per cent. alcohol we can make 95 fluidounces of 20 per cent. But suppose the question is: How much 20 per cent. alcohol could be made from 5 fluidounces 95 per cent.? It is a case of simple proportion.

If 20 fluidounces 95 per cent. give 95 fluidounces 20 per cent., 5 fluidounces 95 per cent. (¼ of 20) will give us ¼ of 95 fluidounces 20 per cent., or 23¾ fluidounces.

Expressed in proportion:

$$20 : 5 :: 95 : \times$$

$$\times = \frac{5 \times 95}{20} = 23\tfrac{3}{4} \text{ fluidounces.}$$

It is important that this be understood. The rule, by the way, applies *exactly* only when there is no diminution in volume.

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CHAPTER IV

HEAT

HEAT is that form of molecular motion which produces the physiologic sensation we call warmth, this molecular motion being produced by friction, electricity, light, or chemical action. In order to obtain a clear understanding of heat, a comprehension of the molecule as explained on p. 345 is essential. Suffice it to say here that molecules are very minute particles of matter, and these molecules, working among themselves, produce friction. That *friction* is the source of heat is well known, and can be demonstrated by such simple experiments as rubbing one surface on another when both become hot. This is shown by rubbing the finger rapidly on a piece of wood, when the sensation of warmth is transmitted to the body. It is also known that when any metallic body, such as an axle, rubs rapidly on its bearings, if the axle is not well greased to prevent this friction, the heat produced is sufficient to set fire to the surrounding objects, producing the condition called "hot box." Primitive people, such as Indians, becoming adept at the art, were able to kindle fires by rubbing two pieces of wood together.

In each case we have a striking illustration of friction as a source of heat.

Another source of heat is *electricity*, and in such cases the friction of the molecules of the non-conductor produces heat. In many cases the resistance causes the substance to glow or become incandescent. Such is the basis of the incandescent electric light in which the electricity is forced through a filament of poorly conducting carbon, the molecules of carbon, in resisting the electric pressure, being heated sufficiently to become incandescent.

A discussion of the principles of electricity is beyond the scope of this work, and for details of this force the reader is referred to any standard text-book of physics.

Suffice it here to state that electricity is a molecular condition, and that this condition is transmitted from one molecule to another with more or less rapidity, dependent on the character of the substance influenced. Matter which rapidly transmits the electric condition from one molecule to another is called a conductor of electricity, while matter the molecules of which do not transmit the condition is said to be a non-conductor or a poor conductor.

As the question of conduction of electricity is a purely relative matter —all bodies transmitting the condition to an extent more or less great— the terms above mentioned are gradually becoming obsolete, and the words "conductivity" and "resistance" being substituted to cover the respective meanings. When we talk of "the electric current" passing through a wire, we mean that the electric condition affecting the end molecule of the wire is rapidly transmitted to the adjoining molecule, and thence from one molecule to another, the whole length of the wire. This being clearly understood, we can use the simpler term, "passage of the electric current," in the following explanations.

Electricity passes rapidly from molecule to molecule through a conductor; but if compelled to run through a non-conducting substance, it requires a current of high potential, of great force, to overcome the resistance of this body.

Light also affords a minute amount of heat. Heat, light, and electricity are so-called physical forces affecting molecules, and are, under certain circumstances, convertible one into another.

We have just seen that electricity is converted into heat; inversely heat can be converted into electricity.

By applying heat to two metal plates in close contact with each other, an electric current is formed in the apparatus known as the "pyro-electric battery." Hence it is not strange that light can be converted into heat, although the amount produced is very minute and very difficult to measure, inasmuch as almost invariably all sources of light are also sources of heat, and, therefore, it is very difficult to isolate light from its accompanying heat.

Chemical action is the chief source of heat. This phenomenon, which is fully described on p. 347 means a breaking up of the molecules of a substance, with the formation of new molecules. This decomposition is accompanied with considerable movement of the molecules and their constituent atoms, thus producing a form of friction and, therefore, producing heat.

Combustion.—Most chemicals reacting on one another produce heat, although in some cases the reverse is true. As an illustration of heat produced by chemical action, iron combined with iodine in a test-tube in the presence of water will so heat the test-tube as to render it difficult to hold same in the hand. Likewise, sulphuric acid combined with solution of soda produces great heat, and numberless other illustrations could be given. The production of heat by such chemical action is different from the chemical action in the burning of wood. The invariable accompaniment of the latter being flame, such form of chemical action is called *combustion;* that is, chemical action accompanied by heat and *light.* We know that wood is composed of hydrogen, oxygen, and carbon; that the air around us contains oxygen, and that by applying a flame to the wood there is commenced a chemical reaction which results in the formation, from the carbon hydrogen and oxygen that is present, of carbon dioxide (CO_2) and of water (H_2O).

In this chemical reaction, as in the formation of ferrous iodide, heat is produced, and of much greater intensity. So great is the heat that some of the carbon, which in the hurry of the reaction escapes combination with the oxygen, glows with heat, just as does the carbon filament in the incandescent light. To prove the presence of incandescent carbon hold a plate over any luminous flame, when it will become blackened with soot, which is pure carbon. Whenever the combustion—as this reaction, in which the carbon and hydrogen of a substance combine with the oxygen of the air, is called—is accompanied by unchanged carbon glowing with heat, a flame is produced.

Any substance with which we can perform a combustion is called fuel. Such matter is very abundant, and is found in all three states of aggregation—solids, liquids, and gases.

Solid Fuels.—The solid fuels are wood, coal, and charcoal. Wood contains hydrogen and oxygen besides carbon, whereas coal and charcoal consist very largely of carbon. In the case of each fuel the chemical action involved is the combination of the carbon with the oxygen of the air, forming carbon monoxide and carbon dioxide, with more or less particles of unconsumed carbon, called soot.

In burning solid fuels the apparatus designed to contain same is called stove or furnace, and consists fundamentally of the fire-box in which the fuel is held, the chimney or flues for removal of the gaseous products of combustion, and damper or vents for the admission of air necessary to produce the action. Provision is made, by means of grating, for the removal and storage of ashes, which constitute the inorganic salts present in wood or coal.

In order to produce successful combustion the oxygen of the air is absolutely necessary, hence if a furnace or stove is not supplied with sufficient air, the fire within the box will be "smothered" or "go out." This explains the method of smothering a fire by surrounding the burning substance with blankets, thus preventing access of air. In order to produce good combustion, a comparatively good draft of air must be had, the intensity of the draft being regulated by the opening or closing of the vents or dampers, and in large furnaces by the relative height of the chimney or smoke-stack.

For the practical application of combustion of solid fuels the reader is referred to any kitchen-range or house-furnace.

The **liquids** used as fuels are alcohol and petroleum products (gasoline and insurance oil, etc.). In using liquids as fuel there are two methods employed:

If the liquid is not very volatile, such as insurance oil, astral oil, etc., the liquid is sucked up through a wick by capillary attraction, and burned as a liquid off the top of the wick. Such a method is also employed in the burning of the volatile liquid alcohol in the ordinary alcohol lamp (Fig. 36).

In cases where the liquid is quite volatile (as gasoline), the apparatus used for the purpose is so arranged that the liquid is first converted into vapor and this vapor burned. Such is the principle of the vapor stove (Fig. 37), which possesses a great advantage over the wick stoves by having the vapor burned mixed with air, as in the Bunsen burner, thus preventing a sooty flame. Alcohol is also burned in the form of vapor in the so-called "Russian blast lamp," which produces an intensely hot flame (Fig. 38).

Gaseous Fuels.—The gases used to produce heat are coal-gas, acetylene, and natural gas, the first two being manufactured, while the latter is obtained in certain sections of the world by simply sinking iron tubes, through which the gas escapes from pockets under the earth's surface.

As to the manufacture of artificial gas, coal-gas is made by the destructive distillation of coal; details of the manufacture can be found in any advanced work on technical chemistry. Acetylene is produced by the action of water on calcium carbide.

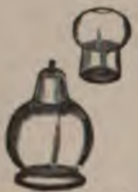
Fig. 36.—Spirit-lamp.

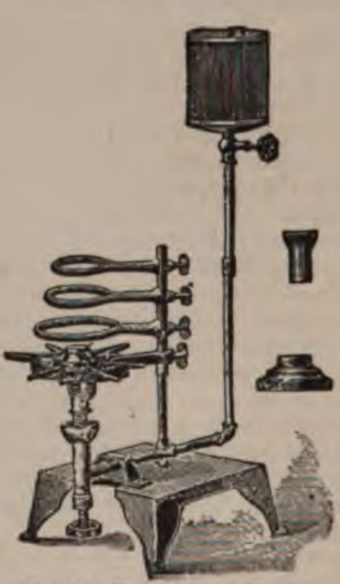
Fig. 37.—Vapor stove and burner.

Chemically, these fuel gases resemble one another, all being combinations of carbon, which furnishes the heat and light when consumed in the presence of air in the operation of combustion in different forms of of burners, according as the intention is to produce a luminous or a non-luminous flame, the latter being used for heating purposes.

A luminous flame is produced in the so-called "fish-tail" burner, in which the gas, as it comes in contact with the air, is ignited by a match or other flame, burning to carbon dioxide and water with incomplete combustion; that is, in the reaction all the carbon is not consumed, and the unconsumed carbon, through the influence of the intense heat generated by the chemical reaction, glows with heat, or, technically expressed, becomes "incandescent." Another example of incandescence is the brilliant light produced when metallic magnesium is burned (p. 460).

Why can some part of the carbon escape chemical combustion?

Bear in mind that the combination is with the oxygen of the air; that the gas evolving from a fish-tail burner forms a mass of some thickness. The oxygen of the air can combine only with the outer surface of this mass, leaving the inside of the flame untouched; just as a tightly closed book, when immersed in water, will be soaking wet on the outside and comparatively dry inside. That gas inside the flame has not enough oxygen to convert all the carbon into carbonic oxide, and the result is that much of the carbon remains unchanged, glowing with the heat of the ardent reaction, and depositing as soot when it passes from the flame. The fish-tail flame (Fig. 39) may be quaintly likened to a chemical factory.

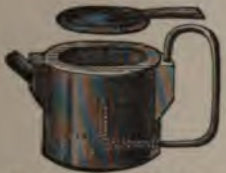

Fig. 38.—Russian alcohol blast lamp

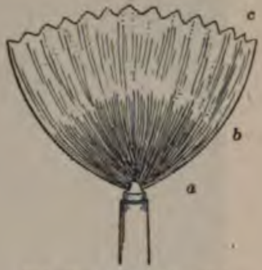

Fig. 39.—Fish-tail flame.

Zone *a* is the reception room, when the crude material that is to be worked up—the gas from the mains—comes in; zone *b* is the workshop where the chemical reaction is carried on with the utmost vigor—where the hydrocarbon of which the gas is composed is broken into carbon and hydrogen, and these in turn combine with the oxygen of the air to form carbon dioxide and water; while zone *c* is the shipping-room, whence the finished products just mentioned are sent away. Since the soot is dirty and inconvenient in cooking, efforts were made to so construct a burner that the gas would have contact with the air (or its oxygen, for air is composed of nitrogen, oxygen, and some carbon dioxide), in parts other than the outer surface, and this is done by mixing the gas with air before burning it in the Bunsen burner. Aside from the great advantage of freedom from soot, the flame of the Bunsen burner is superior to the ordinary flame by reason of its greater heat. In it all the carbon of the gas becomes combined with the oxygen of the air, and it is self-evident the more chemical reaction occurs in a certain space (as in the mass of gas issuing from a burner), the greater will be the heat produced.

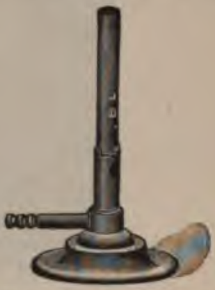

Fig. 40.—Bunsen burner.

With this purpose in view the Bunsen burner is constructed with a few modifications, according to the purpose adapted. In its simplest form it consists of an upright metallic tube with orifices at the bottom, and as the gas rushes upward through the tube, it mixes with air that enters through the bottom orifices, and when emerging from the top of the tube and ignited, it contains sufficient air thoroughly to combine with all the carbon, thus producing carbon dioxide and water, and no unconsumed carbon or soot. Such a burner (shown in Fig. 40) gives a flame in which three zones can be noted on close scrutiny. The top of zone "*a*" is called the reducing flame, while the top of zone "*b*" is the oxidizing flame. This long-accepted view of the gas flame has lately been submitted to criticism, it having been shown that in zone "*a*" all of the carbon has been changed to carbon monoxide, and that the changing of the flame from a luminous to a non-luminous one can be accomplished as well with carbon dioxide, steam or even nitrogen.

In using such a Bunsen burner the flame sometimes "strikes back," that is, the gas which is ignited at the top of the tube finally catches fire at the bottom of the tube, where the unmixed gas emerges, thus producing a sooty flame, and at the same time heating the brass tube, sometimes to a dangerous extent. Such a striking back can be avoided only by having a good current of gas turned on. It can usually be detected from a distance by the peculiar odor of acetylene generated in this incomplete combustion.

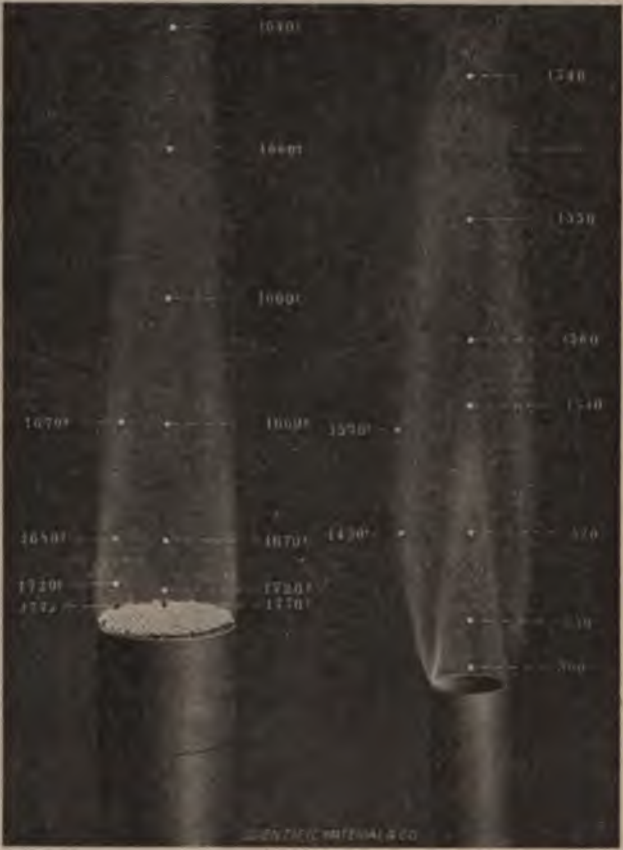

Fig. 41.—Flames of Méker and Bunsen burners.

The Scimatco burner is an improved form of Bunsen burner in which according to the inventor a maximum quantity of gas is produced in a minimum volume of flame; the result is a very hot flame of uniform temperature throughout (Fig. 42).

For the purpose of more extended heating, larger varieties of the so-called gas-stove are obtainable, the most practical of which, from the pharmacist's standpoint, being the Fletcher radial burner shown in Fig. 43, in which the gas is mixed with the air in a horizontal tube, and emerges through radiating slits cut into a central dome, thus making a flat, clean, and intensely hot flame.

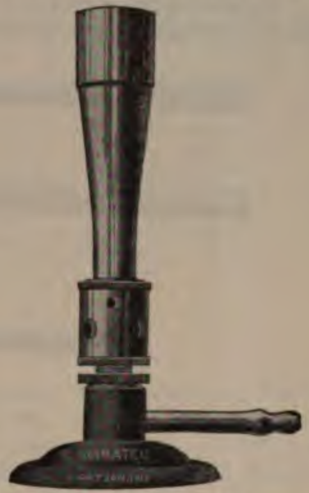

Fig. 42.—The Scimatco burner.

In the old-fashioned form of gas-stove the flame used was a luminous one, and the blackening of the utensils through soot was avoided by placing between the utensil and the flame a wire gauze.

The advantage a Bunsen burner possesses over the ordinary fish-tail burner is due to the fact that the gas before ignition is mixed with sufficient air to produce a complete combustion, and this is of benefit—first, in producing a smokeless flame, and, second, in giving a more intense heat than is produced by the same gas when burned in a fish-tail burner.

That more heat is produced is self-evident when we consider that the heat generated is in direct proportion to the amount of the chemical reaction, and since in the fish-tail burner all the carbon is not consumed, there is, therefore, in such a flame less heat to a given area than will be produced in the same area of a Bunsen burner.

Surface Combustion.—Mixtures of gas and air in proper proportions brought into contact with heated porous material will burn with intense heat without giving much flame. Ovens of this kind are now being constructed.

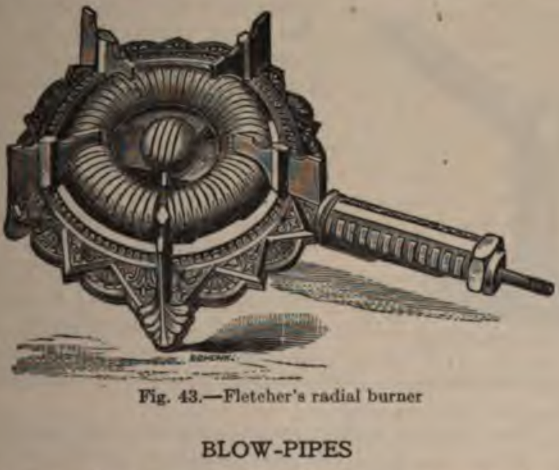

Fig. 43.—Fletcher's radial burner

BLOW-PIPES

The principle of the blow-pipes is merely an extension of the principle of the Bunsen burner. With the blow-pipe, the air expelled from the lungs is blown through the tube upon the flame, this insuring a complete combustion of the gas. The blow-pipe produces more heat than the

Bunsen burner, for the reason that in blowing air into the flame the flame is rendered much sharper and narrower than in a Bunsen burner, and in this way heat produced by chemical action is concentrated to a more limited area; hence by this instrument we are able to make a very intense heat, albeit in a very narrow area.

The **blow-pipe** consists of a bent and tapering brass tube ending in a very minute orifice. the larger end connecting with an appropriate mouth-piece which is pressed firmly against the lips when the air is energetically blown from the lungs through the pipe into the flame. In the cheaper forms of such blow-pipe, where no mouth-piece is provided, the larger end should be fitted with a piece of rubber tubing to prevent the lips coming in contact with the brass, which causes irritation. The continuous blowing of air through the blow-pipe is merely a matter of practice, the expert being able to inhale through his nose at the same time that he forces the air from his lungs through his mouth into the blow-pipe, and this must be done if a continuous flame is desired (Fig. 44).

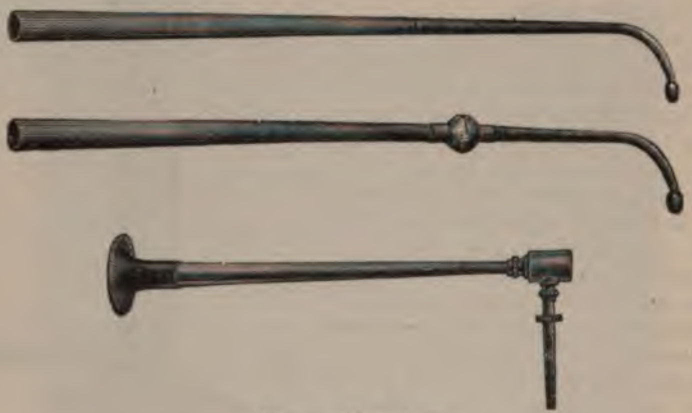
Fig. 44.—Blow-pipes.

The blow-pipe is used entirely for minute operations, such as small chemical work, or for insignificant cases of soldering in the jewelry business. For large operations in which a concentrated flame of high intensity is desired the *blast lamp* (Fig. 45) is used, and this is merely a modification of the blow-pipe in that the air is furnished by means of the bellows rather than by the lungs, and thus the instrument can be made larger.

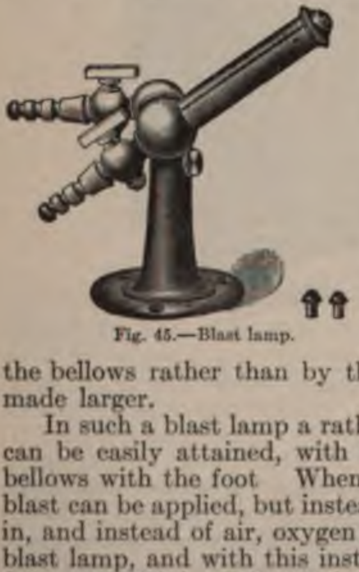
Fig. 45.—Blast lamp.

In such a blast lamp a rather large flame of great intensity (1700°C.) can be easily attained, with the sole physical outlay of operating the bellows with the foot When a very intense flame is desired, the same blast can be applied, but instead of illuminating gas, hydrogen is pumped in, and instead of air, oxygen is supplied. This forms the oxyhydrogen blast lamp, and with this instrument a heat sufficient to melt platinum (about 2000°C.) can be attained.

Electricity is also used for the production of heat, and in future will play a more important rôle in our domestic economy. Even now electric stoves are used for warming purposes, while the greatest artificial heat is derived by the use of the Moissan electric furnace.

An interesting method of production of heat without flame is shown in the use of *thermite*. (See p. 490.)

The following table of relative temperatures of the commonly used heating appliances may be of interest.

Bunsen burner (Fig. 40):	
Lower part of zone "*a*"	300° to 500°C.
Zone "*b*"	1540° to 1560°C.
Méker burner	1640° to 1675°C.
Fuel combustion maximum	2000°C.
Oxyhydrogen blow-pipe	2200°C.
Electric arc, common electric furnace	2000° to 3500°C.
Moissan electric furnace	4000°C.
Oxy-acetylene flame	6000°C.

BATHS

Baths in pharmacy are devised for uniform distribution or for the limitation of heat. Thus the heat of a Bunsen burner, while very satisfactory, is apt to be more intense on one portion of the utensil being heated than on another, and to this cause is due most of the fractures on heating glass and porcelain utensils.

It is a dictum that, in heating substances in porcelain or glass utensils, the direct heat of a Bunsen burner should never be applied, but the flame should be uniformly distributed in the several ways at our disposal. The simplest form for the uniform distribution of heat is a sheet of asbestos or of tin, by which the cylindric flame of the Bunsen burner is spread out to the entire surface of the interposing medium, and a uniform heat is in turn transmitted from it to the container above.

Wire Gauze.—Far more convenient than these, however, is a piece of gauze of iron or copper wire. Through such gauze the heat more readily penetrates than through asbestos, and at the same time the heat is as uniformly distributed by reason of the fact that the wire of which the gauze is constructed is an admirable conductor of heat, and the moment the flame comes in contact with the gauze, each of its many filaments aid in drawing the heat to every portion of the gauze. This has the effect of chilling the flame itself, hence such flame cannot pass through a wire gauze until the gauze has become heated to a temperature almost equal to the flame.

On this principle is based the construction of the Davy's safety lamp for use in mines, the use of which is of no pharmaceutic importance.

This phenomenon also explains why smoke cannot penetrate through such gauze, hence the value of gauze in the old form of gas-stove.

Sand-baths.—A sand-bath consists of a suitable flat dish in which is put a sufficient quantity of sand, the container of the liquid to be evaporated is placed therein, and the sand is piled around so as to completely surround it. Heat by means of the Bunsen burner or other flame is applied under the dish, and is gradually uniformly transmitted to all portions of the heating substance.

In this form of bath the heat is limited only to the amount produced by the burner, the sole aim being to distribute the heat uniformly.

Liquid Baths.—These consist of a suitable dish containing the liquid which is to be heated, the heat of which is in turn transmitted to the substance which it is desired to make hot.

The liquids used for this purpose are oil, glycerin, salt water, and water.

The *oil-bath*, like the sand-bath, uniformly transmits heat, but in addition thereto limits the amount of heat by reason of the fact that when the temperature of 260°C. is attained, the oil begins to burn; that is, undergoes decomposition, with the formation of the stifling vapors of acrolein, which serve as a warning to the operator that a high heat has been attained.

Glycerin baths act on the same principle of operation as the oil-bath, and are limited for the same reason to 250°C. Both forms of baths are not so much used now, by reason of the fact that they do not really limit heat, and their method of warning to the operator is too disagreeable to be popular.

Toluene and *xylene baths* have, therefore, been constructed. (See Fig. 46.)

These liquids, boiling at 110°C. and 140°C. respectively, are placed in a jacketed vessel provided with a long glass tube, which acts as an upright condenser, causing the vapors to chill to a liquid and drop back into the container. In applying heat to such a bath the temperature rises to the boiling-point of the liquid, and the vapors, being condensed and returned to the container, are not lost; hence in such a bath we have not only the limit of temperature, but also a practically perpetual operation.

A *salt-water bath* is based on the same principle as the water-bath, save that it consists of an aqueous solution of some salt whereby the temperature of the boiling liquid is raised.

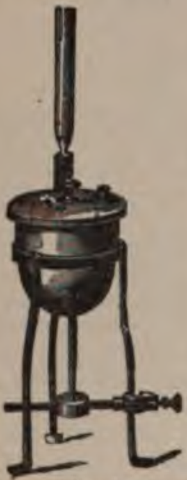
Fig. 46.—Meyer's toluene bath.

A bath made of salt water—saturated solution of sodium chloride—was formerly considerably used under the Latin name, "balneum maris." Such a bath, however, possesses the great disadvantage of losing water by evaporation, with solidification of the remaining saline solution. It is, therefore, comparatively little used.

A saturated solution of sodium chloride boils at 108.6°C.; of potassium chloride at 108.5°C., of sodium sulphate at 102.8°C.; of potassium sulphate at 101.3°C.

Water-baths.—In these the liquid to be used is water, and since water boils at 100°C., the temperature of the bath never rises above that point. A consideration of why water does not boil over 100°F. is left for a subsequent page, and, therefore, attention need be paid only to the various forms of water-bath (Fig. 47).

There is comparatively little necessity for buying expensive apparatus for use as a water-bath. Any tin pail filled with water in which the evaporating dish can be rested, or into which the flask can be sunk, can be used. An excellent form of expensive water-bath is a continuous steam apparatus shown in appended cut (Fig. 48). In this the water trickles from faucet into the well, *a*, the excess passing into the drain by overflow pipe *b*. A lighted Bunsen burner is placed beneath the well, and the amount of water is rapidly converted into steam.

Steam Bath.—The steam bath differs from the water-bath inasmuch as the substance to be heated comes in contact with steam rather than with boiling water. While steam possesses the same temperature as boiling water (100°C.), it has a much larger actual quantity of heat, as will be explained under the subject of Latent Heat (p. 85).

Suffice it, therefore, to say that while in the steam bath, where the steam is brought into contact with the object to be heated at the ordinary atmospheric pressure, it will transmit to the same a temperature of 100°C.; on the other hand, if the apparatus is so arranged as to bring steam under pressure into the bath, a higher degree of heat can be attained. Thus, under the normal atmospheric pressure, 14.7 pounds to the square inch, steam has a temperature of 100°C., while if steam is forced in until the pressure of 100 pounds to the square inch is obtained, said steam will have a temperature of 164°C. Steam of any pressure above that of the normal atmosphere is said to be superheated. In large manufacturing concerns steam, either under normal pressure or in the superheated state, is practically the only form of heat used for the evaporation of delicate materials, as under such conditions there is little danger of decomposition of the product.

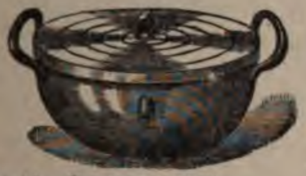

Fig. 47.—Copper water-bath.

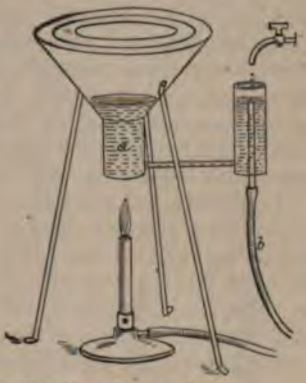

Fig. 48.—Meyer's water-bath.

As steam baths have little practical application in retail pharmacy, a further consideration of the subject is omitted, the reader being referred to some text-book on advanced physics for information concerning laboratory steam kettles used for open pressure, and steam coils in which the steam can be heated under normal pressure or in superheated condition. A well-known variety of steam coil is the steam radiator, so largely used in heating houses.

The advantage a steam coil possesses from the manufacturing standpoint is that it can be placed directly into the kettle containing the substance to be cooked, and thus the substance can be directly heated, with practically no loss by radiation.

VALUATION OF HEAT

While we commonly speak of a thermometer as an instrument used to measure heat and cold, this definition is only partly true, as by means of the thermometer we measure the intensity of the heat, but not the actual quantity produced. Thus, while it is true that with a flame producing a temperature of 500°C. we can accomplish more heating in a given time than we can with a flame of 150°C., nevertheless, if we use a flame of 150°C. for a sufficient length of time, we can usually accomplish as much as with a 500°C. flame for a shorter time, although there are, of course, certain operations in which the intensity of heat is essential and a lower intensity would not do, even though applied for a proportionally longer time.

For measuring the actual quantity of heat—the amount of work done by a flame—the unit called the calorie has been devised.

A calorie represents the amount of heat necessary to raise one gramme of water from zero to one degree Centigrade, and will be spoken of more fully in the discussion of latent heat. There is also the so-called large calorie which equals 1000 "small" calories.

THERMOMETERS

Thermometers are instruments used for measuring the intensity of heat, but not the quantity thereof. Most of these instruments are based on the expansive power of certain liquids and gases. It is characteristic of a large number of varieties of matter to expand with a rise in temperature and, indeed, in regular proportion to the increase in temperature. Thus, an iron bar when heated expands, and if the expansion is limited to the longitudinal direction by encasing the bar in some way so as to prevent excessive lateral expansion, the expanded bar can be made to operate on a lever which moves a needle on a dial, and thus represents the intensity of heat, or the temperature. Such is the simplest form of the so-called *pyrometer*, which is intended to indicate temperatures greater than those shown by the ordinary form of thermometer.

To obtain an accurate thermometer the expanding substance should be liquid or gaseous, and in the early days such forms were devised, the first being by Galileo, who took a glass tube filled with alcohol and, as the heat was increased and the liquid expanded, it of necessity rose in the tube, and the rise could be measured, and in this way the rise in temperature was crudely estimated.

Similar rough instruments were devised from time to time, but the first step in the scientific direction was made by Fahrenheit between 1709 and 1724. Fahrenheit's first improvement was to use mercury in the thermometer instead of water or alcohol. The expansion of mercury is very delicate, and the density of this liquid being so much more than water, it would require a great deal less of same than of water or alcohol; hence in the Fahrenheit thermometer a much smaller tube was necessary than in the alcohol thermometer.

It is claimed that Ismail Boullian made the first mercury thermometer in 1659, but this was not used at the time that Fahrenheit devised his thermometer.

Fahrenheit also devised the first acceptable system of graduation, and this method, somewhat modified, is in use to this day. In graduating this thermometer Fahrenheit set about to find absolute zero, and finally decided that the greatest cold possible was that produced by a mixture of ice and salt. He prepared such a mixture, plunged his thermometer into same, and marked off the place where the mercury stood at this temperature, and denominated this point zero.

That the temperature of ice and salt is the greatest cold produced has proved false. It is usual, every winter, to find certain sections of the world where the temperature falls to as low as 50° or 60° below zero, while by chemical means the temperature of −271°C. has been attained, and experiments of physicists seem to point to the fact that absolute zero is −273°C.

Fahrenheit, however, having arranged his zero to his own satisfaction, next turned to look for another authoritative standard, and for this he determined upon the temperature of the blood. He, therefore, placed his thermometer under his arm, noted the point to which the mercury rose, marked the space, and, for some reason not explained, denominated this "24." The space on the tube between zero and 24 he divided into 24 spaces called degrees, and his later experiments showed that on such a thermometer melting ice registered 8°.

Such a thermometer was intended for practical use, but it was soon found that the range of 24 between his zero and the temperature of the blood was scarcely sufficient for practical purposes, hence he devised a thermometer in which his former degrees were multiplied by four, and on such thermometer the freezing-point of ice was 32°, and the temperature of the blood 96°, and in terms of these degrees the boiling-point of water registered 212°.

Fahrenheit's thermometer, while a step in the right direction, has the misfortune of being based on an unscientific standard, as ice and salt do not produce the lowest known temperature, and, moreover, do not always represent exactly the same temperature experience has long since proved. In the same way the statement that 96° is the temperature of the blood is not absolutely accurate, inasmuch as the blood's temperature varies according to the condition of the person.

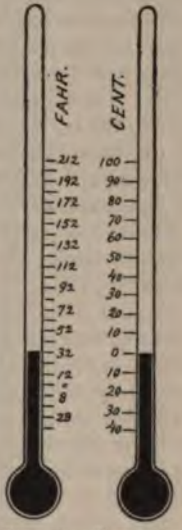

Fig. 49.—Comparison of Fahrenheit and Centigrade thermometers.

The graduation adopted by Réaumur in 1730 was a decided advance over the Fahrenheit system, inasmuch as Réaumur took for zero an absolute standard very easily determined (the melting-point of ice), and chose for his higher standard the equally accurate and easy unit of the temperature of boiling water. The latter, however, he denominated 80°, and the scale was, therefore, much improved by Celsius in 1740 in devising his Centigrade system, in which the melting-point of ice is zero and the boiling-point of water 100°, and the space between was accurately divided into 100 parts.

A comparison of the thermometers can be best shown by appended sketch (Fig. 49), in which it can be noted that while in the Fahrenheit thermometer the space between the freezing-point and boiling-point is divided into 180° (212°–32°), the same space on the Celsius is divided into 100°. Therefore, we can sum up the relative values as follows:

$$180°\text{F.} = 100°\text{C.}$$
$$1.8°\text{F.} = 1°\text{C.}$$

To sum up:

Fahrenheit............	Melting-point, 32°	Boiling-point, 212°	Difference, 180°
Centigrade............	" 0°	" 100°	" 100°

which evolves the very important point that 1° *Centigrade equals* 1.8° *Fahrenheit.*

If both Fahrenheit and Centigrade had the same zero, or starting-point, the conversion of one into the other would be very simple, as it would only mean multiplying or dividing by 1.8, but where zero is on

Celsius (or Centigrade) scale, 32° is on the Fahrenheit, and this 32, accordingly, comes in as a factor in changing one kind of degree into the other.

The rules of conversion can be abbreviated thus:

C. into F.: × 1.8 and + 32; F. into C.: − 32 and ÷ 1.8, to which might be added for temperatures *below the freezing-point*, C. into F.: × 1.8 and − 32; F. into C.: +32 and ÷1.8.

To explain this, sketch a thermometer, similar to that pictured above, with Centigrade markings on one side and Fahrenheit on the other, beginning with a line marked 0 on the Centigrade side and 32 on the Fahrenheit.

Suppose we have 50°C. as a starter:

50 × 1.8 = 90.0—90 *Fahrenheit degrees* but not *degrees Fahrenheit*. It means 90 Fahrenheit degrees above the melting-point of ice, and this point is 32 Fahrenheit degrees above the Fahrenheit zero. To get the actual *degrees* Fahrenheit in 50°C. we must add this 32 to the 90 already gotten, when we find that 122°F. = 50°C.

We will try the reverse problem: How many degrees Centigrade in 122°F.? We first get this figure on the same basis as zero Centigrade. This we do by subtracting 32 from 122, thus finding how many Fahrenheit degrees 122° is above the melting-point of ice. The difference between 32 and 122 is 90, and this, divided by 1.8, gives us 50. Therefore 122°F. equals 50°C.

Below the melting-point of ice, the matter is a little more difficult of explanation. Let us choose as our example how many degrees Fahrenheit in −35°C.

35 × 1.8 = 63 *Fahrenheit degrees*, not *degrees Fahrenheit*, below the melting-point of ice—63 Fahrenheit degrees below the point that is marked zero on the Centigrade scale. The point marked zero on the Centigrade scale means 32° Fahrenheit; so the 63 degrees we have spoken of will be partly above and partly below zero Fahrenheit; 32 degrees of it will be above zero, the balance (63−32), which is 31°, will be below zero Fahrenheit, and thus we see that −35°C. is equal to −31°F. Inversely, if we want to know the value of −31°F. in the Centigrade scale, the first thing to do is to find how many Fahrenheit degrees there are between −31° and that point on the Fahrenheit thermometer which equals 0°C. This point is 32°F. If there are 31° below zero and 32° above that point to 0°C., then the number of Fahrenheit degrees between 31°F. and the point marked zero on the Centigrade scale is 31 + 32 = 63.

In other words, −31°F. is 63 Fahrenheit degrees below zero Centigrade. Take 63, divide by 1.8, and we get 35, showing that −31°F. equals −35°C.

It would be useful for the student to calculate in Centigrade degrees the value of −40°F. (see p. 549).

Conversion of Fahrenheit markings into Réaumur and Réaumur markings into Fahrenheit is of comparatively little importance in American pharmacy; therefore, a brief statement of the factor will suffice.

If 0.8°R. = 1.8°F.
Then, 1°R. = $^{10}/_{8}$ × 1.8, or 2.25°F.
Then to convert Réaumur into Fahrenheit multiply by 2.25 and add 32.
Then to convert Fahrenheit into Réaumur subtract 32 and divide by 2.25.

Varieties of Thermometers.—The usual form of thermometer consists of a glass bulb to which is attached a capillary tube. In it is placed a sufficient quantity of boiled mercury to fill the bulb and the lower portion of the tube. In the cheaper form of thermometer air is allowed to remain in the rest of the tube, whch is sealed at the other end. In such thermometers, however, after continued use, the mercury is gradually oxidized by the air, rendering the instrument less accurate; therefore in the finer grades of thermometer the air is replaced by pure nitrogen, or a vacuum is made in the tube. This bulb and tube is then attached to a scale in the several ways that convenience suggests, the cheaper forms of thermometer being merely fastened to a piece of wood on which the scale is marked, while the chemical and pharmaceutic thermometers are usually inclosed in a glass tube inside of which the scale is placed, the intention in this case being to make the thermometer of cylindric form and sufficiently small to permit insertion through a cork, and then into the neck of a flask. On such thermometer the scale is made of paper or porcelain placed inside of the outer tube, or else it is engraved on the outer surface of the outer tube, the latter being particularly the case in the exceedingly small and delicate thermometers used in estimating boiling- and melting-points (Fig. 50).

In purchasing a thermometer for pharmaceutic purposes, always avoid those with paper scales, for should one be heated above 125°, it will scorch and even char, and the reduction in cost, as compared to the porcelain scaled thermometer, is too little to justify the economy.

It is needless to say that a Centigrade thermometer should be so accurately adjusted that the zero mark coincides with the height of the mercury column when plunged into melting ice, and that the 100° mark should agree with the height of the mercury column when placed in the temperature of steam.

To test thermometers for this purpose is a very simple matter. Such tests should be made from time to time on every thermometer, used as the glass in the thermometer, on aging, undergoes more or less contraction and therefore is apt to become inaccurate. Details of this testing will be found in Part VI.

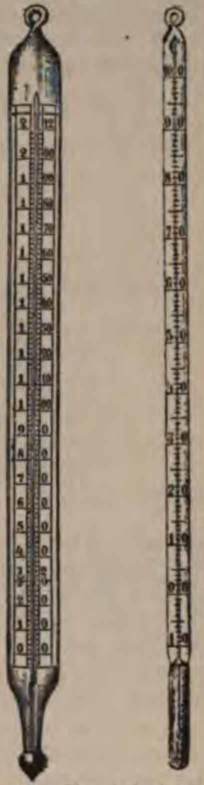

Fig. 50.—Chemical thermometers.

A modification of the thermometer, sold in pharmacies, although not used in pharmaceutic operations, is the well-known fever thermometer. This is generally limited to the temperature of the human body—say from 90° to 110°F. Thermometers of such limited marking can, of course, be made smaller than those of larger scope, hence are more convenient for carrying by a physician.

A popular form of this instrument is the so-called "self-registering thermometer," in which a portion of the mercury rises to the greatest height in the operation, and does not return with the rest of the mercury in contracting, thus leaving a register of the patient's temperature for examination by the physician on his return visit.

This break in the mercury column must be remedied before the thermometer is used for another operation, and this can be done very simply by grasping the thermometer by the upper end, raising same above the shoulder, and giving it a downward circular sweep. This, repeated several times, will remedy the break. The same treatment applies to a chemical thermometer when such a break in the filament occurs.

In some cases, however, the break is so persistent as to resist these efforts, when it can be brought down by gently warming the thermometer until the mercury rises to the broken part and forces same up, and then shaking the mercury down as above mentioned.

Other Varieties of Thermometers.—In pharmacy the thermometers above mentioned are practically the only ones employed, and to such thermometers the measure of the temperature is limited to minus 40°C., the freezing-point of mercury, and to plus 360°C., the boiling-point of mercury. In technic the measurement of higher temperatures is often desired, and for such purposes modifications called "pyrometers" are employed. The simplest form of pyrometer is the iron bar mentioned on p. 76. In another form the bulb and tube are made of finest porcelain, filled with air, which expands on heating, and the expansion is measured by the pressure of the air on a mercury column.

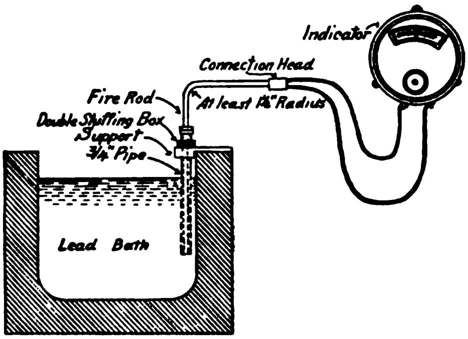

Fig. 51.—Lead bath and pyrometer (for high heat experiments).

A more modern form of pyrometer is one in which electricity is employed, this acting on the principle that certain substances on heating show more resistance to electricity than when cold; indeed, in exact proportion to the increase of temperature. Therefore in such an instrument a current of electricity is conducted through the metal, which acts as the thermometer, and the temperature is estimated from the reading of the resistance gauge, or ammeter.

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CHAPTER V

APPLICATIONS OF HEAT

In studying the dozen or more pharmaceutic processes involving the use of heat, we note that they can be best understood when presented in the following tabulated form:

I. Chemical change in the heated product:

1. **Substance is inorganic, is strongly heated, and gives off gas.**	(a) CO_2 eliminated, *calcination*. (b) Gas eliminated with a flame, *ignition*. (c) Gas eliminated with crackling sound, *deflagration*.
2. Substance is organic.	(a) Strong heat without access of air, *carbonization*. (b) Strong heat with access of air, *incineration*. (c) Moderate heat only, *torrefaction*.

II. Physical change produced in heated product:

1. Solid temporarily changed to liquid, *fusion*.
2. Solid or liquid temporarily changed to gas, *vaporization*.

The modifications of vaporization can best be tabulated as follows:

Method	Object Sought	Name of Process
Simple vaporization	(a) Liquid residue	Evaporation.
	(b) Solid residue	Desiccation. Exsiccation. Granulation.
Vaporization and condensation	(a) Volatile liquid	Distillation.
	(b) Volatile solid	Sublimation.

Discussing the several processes individually we find the following points of interest and importance.

Calcination is the process of strongly heating a carbonate, whereby the gas, carbon dioxide, is driven off and the oxide of the metal remains.

Note the similarity between the words "calcination" and "calx." Calx is the Latin name for lime, calcium oxide, CaO, which is made by strongly heating calcium carbonate, $CaCO_3$, when carbon dioxide, CO_2, passes off. By the identical process—calcination—the oxides of magnesium and zinc are produced, as the following comparison shows:

$$\begin{array}{r} CaCO_3 \\ CO_2 \\ \hline Ca\ O \end{array} \qquad \begin{array}{r} MgCO_3 \\ CO_2 \\ \hline Mg\ O \end{array} \qquad \begin{array}{r} ZnCO_3 \\ CO_2 \\ \hline Zn\ O \end{array}$$

The results of above subtraction—the remaining oxides—are said to be "calcined."

While the largest operations of calcination are performed in huge plants of masonry called lime-kilns, in the laboratory the substance to be calcined is usually placed in an evaporating dish (see p. 90) or in a crucible, the source of heat being a blast lamp.

Crucibles are utensils of various sizes, shapes, and materials, according to the objects for which intended. The name crucible dates from the middle ages, when the alchemists (the forerunners of the chemists), in invoking Divine aid in their operations, marked utensils of this character with the sign of the cross (Latin, "*crux*").

The modern crucibles are made of the following materials:

Fire-clay or *Hessian crucibles* (Fig. 52) are very cheap and convenient apparatus for conducting high heat experiments. They usually come nested, in sizes ranging from 15 to 500 mils. Their chief drawback is that they are poorly annealed, and are therefore liable to break. Moreover, they are too porous to hold water.

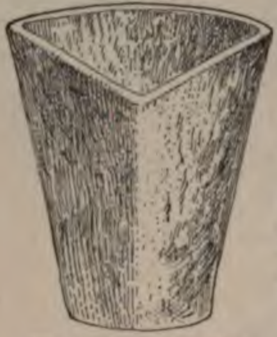
Fig. 52.—Hessian crucible.

Graphite crucibles are more expensive, but are durable. They are commonly called "black-lead crucibles," and are of the same material of which the "lead" of pencils and the cake stove-blacking is composed. They are used more for chemical than for pharmaceutic work, as is also that form of crucible, "the cupel," which is made of bone-ash and used exclusively in metallurgy.

Porcelain crucibles are the most popular of all forms of crucibles, they being comparatively durable, easy to clean, and moderate in price. They can be obtained in all sizes, but the most convenient are those of 15 to 30 mils capacity (Fig. 53).

Platinum crucibles are too expensive to be of ordinary pharmaceutic use, but the purchase of a platinum crucible is by no means a bad investment, as when the instrument has become worn out, the platinum of which it is composed can be sold at a price but little below its original cost. The most convenient size of platinum crucible is one of 10 to 15 mils capacity. They are of great value, because durable and because possessing powers of resistance against chemicals far greater than other metals. This great advantage must not be abused, however, for it should be clearly remembered that sulphides, hypophosphites, potassium and lead salts affect platinum, ruining the crucible in which they are heated.

Appliances necessary to the successful handling of crucibles are *crucible tongs* (Fig. 54), which are used for lifting crucibles and *triangles* on which they rest while being heated. These, as shown in cut, primarily consist of iron wire covered by clay piping, hence obtainable at small cost. The triangle rests on or is supported by a *tripod* (Fig. 55) or else on the ring of a retort stand.

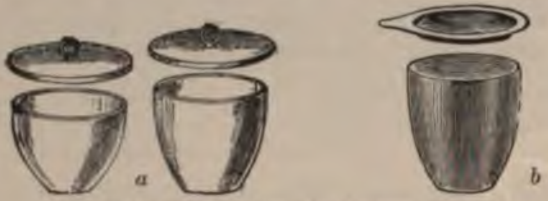

Fig. 53.—Porcelain crucibles (*a*); platinum crucible (*b*).

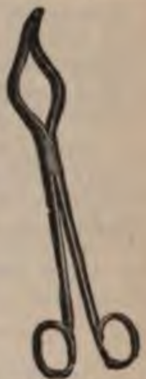
Fig. 54.—Crucible tongs.

Ignition is the process of heating inorganic matter strongly, whereby certain portions are driven off in gaseous forms (usually with formation of a flame), leaving the non-volatile residue. This process is used in pharmacy in some analyses, for example: the United States Pharmacopœia of

1890 directed in a test for sulphurated antimony, that the same, on being heated, should lose its sulphur by ignition, leaving a residue consisting chiefly of antimony oxide. Likewise ignition is used in the burning of iron pyrites, when the sulphur which it contains combines with the oxygen of the air to form the gas sulphurous oxide, leaving a residue (ferric oxide) behind.

The ignitions of pharmacy are usually performed on platinum foil, in crucibles, or in evaporating dishes, or even on the end of a spatula or knife-blade. Thus the presence of calcium sulphate in a sample of precipitated sulphur is easily detected by igniting a bit of the suspected chemical on the blade of a spatula, when it leaves a residue only in case calcium sulphate is present.

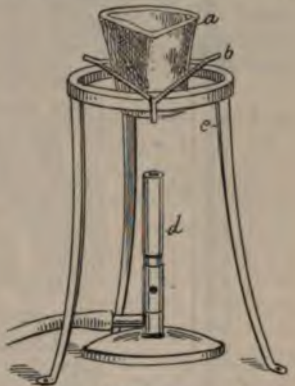

Fig. 55.—Heating crucible: a, Crucible; b, triangle; c, tripod; d, Bunsen burner.

Deflagration is the process of strongly heating a substance readily yielding oxygen, when this element is evolved with a characteristic crackling sound. This phenomenon occurs when potassium nitrate or potassium chlorate is heated, and the process is quite different from that of "decrepitation," which will be explained in the chapter on Crystallization.

Deflagration is used in no process of pharmacy, but it is of value in the testing of some official chemicals, such as potassium nitrate. To produce deflagration the salt is sprinkled on hot coals, or is heated on platinum foil or is placed in a deflagrating spoon (Fig. 56).

Carbonization is the process of strongly heating an organic substance (that is, a substance containing carbon) in a vessel protected from access of air. Under this treatment the hydrogen and oxygen usually found in organic substances associated with carbon pass off in the form of water, leaving behind the carbon or charcoal.

This process is rarely employed in pharmacy, and when utilized may be performed in a rather tightly covered crucible. The typical example if carbonization is the manufacture of charcoal—"the charcoal burning"—an industry of the southern United States.

Fig. 56.—Deflagration spoon.

If carbonization is carried on in a retort and the volatile products collected, the process is called *destructive distillation*. By such destructive distillation of wood, wood-alcohol, acetone, and acetic acid are now made.

Incineration is the process of strongly heating an organic substance with access of air, whereupon the carbon, as well as the hydrogen and oxygen, is dissipated, as oxidation products, and nothing is left but inorganic salts found in the original substance, and commonly called *ashes*.

Incineration is like carbonization, save that the former process is performed in a utensil where the air cannot get at the organic substance, while in incineration the air has full access. This makes the important difference that in carbonization the residue, after heating, is carbon or charcoal and inorganic salts; while in incineration the carbon combines with the oxygen of the air to form the gas, carbon dioxide, CO_2, which passes off, leaving behind only a small residue (ashes) consisting of inorganic salts. Such an operation is every open fire; such is the process of cremation. Its use in modern pharmacy is limited to chemical examinations, the amount of ash yielded by drugs being in some cases a valuable criterion of quality. Such ash estimations are performed by carefully drying a crucible by heating in Bunsen burner for fifteen minutes, weighing same after cooling in a desiccator (p. 110), carefully placing the drug in the crucible, and weighing, incinerating same, and finally weighing the remaining ash.

In alchemistic times the ashes from the certain plants were supposed to be of great value in medicine. Thus the ashes of wormwood, which modern chemistry has shown to consist chiefly of potassium carbonate, was highly esteemed under the name of "sal absinthii," or "salt of wormwood," two synonyms which still cling to the commercial salt.

Torrefaction is the process of more moderately heating organic matter with access of air, in which case the active principles of the substance are not eliminated, but are merely modified. The process is what is commonly called "*roasting*," and a familiar illustration is the roasting of coffee, peanuts, etc. In pharmacy it is an obsolete process, although formerly "*torrefied rhubarb*" enjoyed considerable vogue.

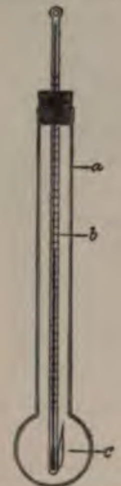

Fig. 57.—Melting-point apparatus: *a*, flask; *b*, thermometer; *c*, substance in tube.

The operation is performed by placing the drug in an evaporating dish, watch-glass, or crucible, and exposing it to a steady moderate heat; best applied by means of a drying oven (p. 110).

Fusion is the process of converting a solid into a liquid by means of heat without the aid of a solvent, the object usually being to enable the straining of the fluid mass or the molding of it to some special shape at the moment of solidification. The process is so well known that it is scarcely necessary to do more than refer to the well-known operation of melting wax as an illustration of fusion. This, therefore, is an official fused substance, as is also the official molded silver nitrate.

Substances are fused in any appropriate vessel—crucible, test-tube, or dish—and the melted mass strained or poured into molds as desired, it being hardly necessary to state that since the liquid returns to solid form as soon as the heated mass reverts to ordinary temperature, the fused condition is merely temporary.

The *melting-point* of a substance is estimated by placing the powdered mass in a very small tube, attaching this tube to a thermometer, and immersing the thermometer and tube into concentrated sulphuric acid contained in a beaker or flask (Fig. 57). Heat is then applied to the acid, and the moment the substance fuses, the thermometer is read.

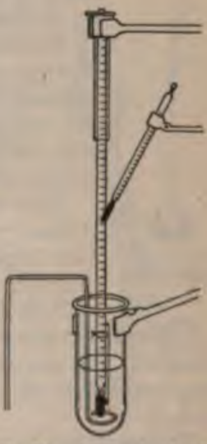

Fig. 58.—Apparatus for taking melting points.

The present pharmacopœia prescribes (Part II, p. 596) very elaborate directions for taking melting-points and the illustration (Fig. 58) is taken from that work. The extra thermometer placed above the one used for determining the actual melting-point is to note the temperature outside the sulphuric acid, since the upper part of the thermometer is directly exposed to the air and is likely to give faulty results. The factor of correction is also given in the pharmacopœial explanation.

It does not always happen that the temperature at which a solid fuses (the melting-point) is the same as the temperature at which the fused material returns to its solid form. This last temperature is called the *congealing-point.* Details of estimation of the congealing-point is given in the present pharmacopœia (Part II, p. 599).

Vaporization is a general term meaning the change of a solid or a liquid into a vapor; the latter term meaning the gaseous form of a substance, which at ordinary temperatures is either a solid or a liquid.

Liquids and solids are held together by the force of cohesion exerted by their molecules. In gases, the molecules, instead of being held together, actually repel each other; the force of cohesion is practically overcome. To overcome this requires much energy, and it is into such energy that that surplus heat of vaporization is converted. Steam, when placed in a position in which it can gradually assume normal temperature, reconverts the energy necessary to keep its molecules apart into heat, imparts this heat to the surrounding media, and returns to liquid form. Even so do all volatile liquids, and the process whereby a vapor passes into a liquid form is called *condensation.* This condensation is usually hastened, in general practice, by application of cold water or ice to the vapor.

The form of energy necessary to keep the molecules of a substance sufficiently far apart to maintain the vapor form of that substance is called "*latent heat of vaporization.*" Latent heat can be simply explained as follows: We take a flame that would register 500°C. on a thermometer and put over it a pot of hot water; the temperature of that water will never rise much above 100°C. Possibly it may reach 102° or 103°C., but hardly higher. What then becomes of the surplus heat of the flame? It becomes hidden, it is said; hence the term "latent," from the Latin "*lateo,*" to hide.

But the term is scarcely correct. We learned in Chapter IV. that heat was molecular motion—a kind of energy. Now this energy can be transformed into other forms of energy under certain conditions, and that is what happens in the case under consideration.

Water when it reaches 100°C. is converted into steam—it is changed from a liquid to a gas. This transformation means work. It means expenditure of energy, and the energy needed comes from those 400°C. of heat which we say becomes latent.

One of the fundamental rules of physics is that energy is never lost. We may lose sight of it, but it merely assumes another form. Accordingly, all that energy—all those 400° latent heat in the flame—is to be found in the steam, ready for other work, as can be shown as follows:

Take equal parts of water at 100° and at 0° and the mixture will have a temperature of 50°, the mean of 100 and 0. Take, on the other hand, equal parts of steam at 100° and water at 0° and we get water at 100°. This shows that steam at 100° contains more heat than water at 100°; that this extra heat is used to hold the molecules of the vaporized water apart. The exact quantity of energy has been gaged, and it is found by experiment that one part of steam at 100° is not merely capable of raising one part of water from zero to 100°, but can actually raise 5.4 pounds of water from zero to 100°. Accordingly, 1 pound steam can raise 540 pounds water 1°C., and we, therefore, say the latent heat of steam is 540 calories (the exact figure is 535.9).

This explains why steam is so much more valuable for heating purposes than an equivalent amount of water at the same temperature, as it also explains why steam is so much "hotter" than water at the same temperature, why a steam scald is so much more painful than a scald from boiling water.

The changing of the liquid into vapor occurs at all temperatures. That water, for example, evaporates freely at ordinary temperatures is demonstrated by the fact that a towel soaked in water and hung in such a position as to allow access of air will readily dry, or, in other words, water will evaporate therefrom. However, water evaporates with the greatest facility only when the boiling-point is attained.

The **boiling-point** is of such pharmaceutic importance that it behooves every student clearly to understand when and how *ebullition*, or boiling, commences.

When a pot of water is on the fire, the first part of the liquid to reach 100°C. is that nearest the flame—at the bottom of the pot. It is, therefore, the water at the bottom that is first changed to steam.

Steam is vapor—a state of aggregation in which the molecules tend to get away from each other. They have overcome the force of cohesion, are wild to break bounds and escape into the open air. This tendency of a liquid to expand to a gas is called the *tension of its vapor*.

The steam at the bottom of the kettle has its tension, but it is restrained in two ways. It has above it the weight of the column of water in the pot, and on top of this the weight of the atmosphere, which presses down with the force of almost fifteen pounds to each square inch of surface. Before the steam can escape, before the bubbles of vapor can rise to the surface, the combined restraining power must be overcome by the tension of the vapor of water, and the point where the tension of the vapor overcomes the pressure of the atmosphere is the boiling-point, and is attained only at a certain degree of heat absolutely fixed for each liquid.

Vapor may pass off at temperature under the boiling-point, but it then passes from the surface of the liquid, with little or no disturbance, and takes place rather slowly.

It is only at that supreme moment—that moment when the heat attained is sufficient to raise the tension of the vapor above the pressure of the atmosphere, that the liquid boils; that bubbles of steam arise from the bottom of the heated liquid.

The statement that a liquid begins to boil when the tension of its vapor is greater than the pressure of the atmosphere can be easily demonstrated by the following simple experiment:

A glass tube sealed at one end and about three feet long is exactly filled with mercury, and inverted into a bowl containing the same liquid. It will be noted that the mercury in the bowl will support a column of mercury inside the tube, usually about thirty inches above its surface. The force supporting the column of mercury thirty inches high is none other than the pressure of the atmosphere on the surface of the mercury in the bowl, and if the area of the interior of the tube be one square inch, it will be found that the weight of this thirty-inch column of mercury will be 14.7 pounds.

From this we deduce the statement that the usual atmospheric pressure is 14.7 pounds to the square inch, and this has been proved in other ways.

We thus learn what is meant by the pressure of the atmosphere. Now, in order to demonstrate the second part of the statement just given above, that a liquid begins to boil when the tension of its vapor overcomes the pressure of the atmosphere, we insert into the vacuum in the tube above the column of mercury an appropriate quantity of water, which at ordinary temperatures will have but little effect on the height of the mercury column. The moment we begin heating the water a change occurs, the mercury being gradually pushed down toward the mercury in the bowl by the expansive force of the warmed vaporized water; in other words, by the tension of the vapor of the water. As the heat is continued the pressure of the vapor of the water pushes the mercury farther and farther down; in other words, gradually overcomes the pressure of the atmosphere, and this before the liquid begins to boil.

The moment the liquid begins to boil it is observed that the mercury has been completely forced from its former place, that is, the column of mercury thirty inches high has disappeared—the tension of the vapor of water has become equal to the pressure of the atmosphere.

This experiment can be carried on with equal success, with liquids other than water, in which cases, it is found that the column of mercury is completely forced down from the barometer at the moment the boiling-point of that liquid is reached. The boiling-point of water decreases about 1°C. for each 1080 feet ascent.

That different liquids possess different boiling-points is, of course, too well known to require much comment, but mention may be made that while water boils at 100°C., alcohol boils at 78°, chloroform at 61°, and ether at 35°.

Estimation of boiling-point is discussed in Part VII. and on p. 95. An elaborate method of estimating the boiling-point is given in the present pharmacopœia (Part II., p. 598).

As shown in the table given on p. 81, there are several modifications of vaporization, all of which will now be discussed.

Evaporation, in the strict sense of the word, means the vaporization of a liquid from a liquid, as, for example, the removal of water from glycerin by gentle heat. In a broader sense of the term, however, it includes the removal of liquid by heat from any solution. Thus it is more usual to speak of evaporating a solution of salt than of evaporating water from glycerin.

Conditions Affecting Evaporation.—The rapidity of the evaporation depends rather largely on the following conditions:

First, *amount of heat.*

The greater the source of heat, the more rapidly the evaporation will take place.

Second, *the amount of atmospheric pressure.*

As noted above, the less the atmospheric pressure, the lower the temperature necessary to bring the liquid to the state of ebullition. Thus, while water boils at the ordinary atmospheric pressure of 14.7 pounds to the square inch, at 100°C., the same water, placed in a container from above which the pressure of the atmosphere has been lessened to only 1.7 pounds to the square inch, will boil at 50°C., and, on the other hand, the same water confined in a container in such way that the pressure on the surface of the liquid is 100 pounds to the sqaure inch, will not boil until the temperature of 164°C. is reached.

Therefore, many cases of evaporation are carried on in special apparatus in which the atmospheric pressure has been lessened, such apparatus being called vacuum pans.

Third, *amount of humidity in the air.*

An aqueous solution, on evaporating, is converted into steam which, of course, passes off into the atmosphere, and the rapidity with which the air receives this vapor is in proportion to the amount of moisture already contained in the atmosphere. A dry air naturally absorbs more moisture than will a humid atmosphere, hence liquids evaporate more rapidly in dry air than in humid air.

Fourth, *character of the solvent.*

In evaporating liquids at the boiling-point, the nature of the solvent influences to a greater or less degree the rapidity of evaporation: a thin mobile liquid usually evaporates more rapidly than a dense and viscid liquid. The question of evaporation is not, however, a mere question of relative specific gravities, as is shown by the fact that the very volatile chloroform (boiling-point, 61°) is one and one-half times heavier than water, the volatility of the chloroform being due to the mobility of the liquid and not to its density. The reason a mobile liquid evaporates more readily than does a viscid one is because its molecules, having little adhesion, freely separate from one another, thus affording the exit of the vaporized portion. In the case of viscid liquids, like syrup or mucilage of gum arabic, the molecules do not freely separate from one another, and on evaporation of such liquids this fact can be noted by examination of the bubbles formed as the liquid vaporizes.

The influences affecting evaporation by boiling and evaporation below the boiling-point are of different character, in the first case the main factor being the extent of surface exposed to the heat, while in the latter case it is the extent of surface exposed to the air; hence each of these can best be considered separately.

Evaporation by Boiling.—Since heat is necessary to facilitate boiling, it follows that the greater the surface exposed to the source of heat, the more rapidly the liquid will boil, and this result is obtained not simply because of such broadening of the surface exposed to the heat, but also by the fact that such broadening implies a corresponding decrease in the depths of the liquid. As an illustration, the volume of 100 mils water will have much less depth if poured into a flat dish than if retained in a graduate, and that the lessening of the depth facilitates ebullition can be understood when the fact is noted that the liquid begins to boil not merely when the tension of its vapor is greater than the pressure of the atmosphere, but when such tension is greater than the pressure of the atmosphere plus the pressure of the column of the liquid above. Hence in evaporating at boiling we try to place the liquid in as thin a layer as possible, by choosing flat forms of evaporating dishes and the like.

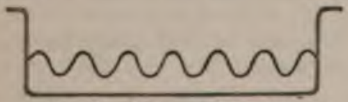
Fig. 59.—Corrugated pan bottom.

Since evaporation by boiling is influenced by the amount of surface exposed to the heat, the character of the vessel plays its part, as certain materials and forms transmit heat better than others. Thus iron and copper vessels are better for evaporation of liquids than are porcelain, because of the greater conductivity of the metals. This statement, however, does not mean an unqualified recommendation of iron and copper utensils for evaporation of pharmaceutic products, as the question of preserving the purity of the chemicals is of far more importance than is the rapidity with which it can be evaporated, and metallic vessels are very apt to contaminate the products.

As to form, a corrugated vessel will transmit heat more readily than a flat-bottomed one, as is self-evident by examination of Fig. 59, where it is seen that a corrugated vessel actually exposes about twice as much surface to the heat as a flat-bottomed vessel of the same diameter.

In the same way a liquid will evaporate more readily in a rough vessel than in a very smooth one. For this reason in boiling water for domestic purposes a rough iron kettle is preferred, as the roughness of the utensil acts the same as does the corrugated bottom of the typical evaporating vessel mentioned above. The external roughness and lack of luster of the vessel is also a contributing factor, inasmuch as finely polished external surfaces act as reflectors of heat as well as light, actually throwing off the heat instead of transmitting it to the interior; hence, the making of boilers and kettles with rough and dark exteriors.

Evaporation Below the Boiling-point.—While in this case of evaporation more attention is paid to the surface exposed to the air than to the surface exposed to the heat, and the two usually resolve into the same thing, because in obtaining the largest surface exposed to the air we use a shallow vessel, even as we do in attempting to increase the surface exposed to the heat.

The pharmaceutic application of evaporation below the boiling-point is generally limited to the desiccation of substances and the evaporation of liquids which are apt to be decomposed when heated on a wire gauze, and, therefore, directed to be heated on a water-bath. While a water-bath itself has the temperature of 100°C., it never transmits that heat to the substance placed on same. The actual temperature of a liquid heated on a water-bath is usually from 90° to 95°C., the surrounding air causing that much loss of heat when transmitted from the water-bath to the substance. For this reason an aqueous liquid cannot be made to boil on an ordinary water-bath and, therefore, the evaporation of such aqueous liquid on a water-bath is rather a tedious matter. The evaporation can be facilitated by constant stirring, this stirring producing the same effect on the liquid as the corrugated bottom of the evaporating dish mentioned above, by increasing the extent of surface exposed to the heat. Stirring the liquid produces waves thereon, and as a wave in its ideal sense represents a corrugation, it means an increased surface exposed to the air. To attempt to evaporate an aqueous solution on a water-bath without constant stirring is practically impossible.

In some cases liquids are evaporated without recourse to any ordinary heat, that is, at the ordinary temperature, and such is called spontaneous evaporation.

Spontaneous Evaporation.—An illustration of this is seen in the drying of clothes when the same are spread to their utmost extent and suspended from lines, thus increasing the surface exposed to the air. Applications of this principle are comparatively limited in pharmacy, as in most cases the ordinary sources of heat are generally cheap enough to permit their use in evaporation.

Two cases, however, in which spontaneous evaporation is used commercially may be cited. In the first case, in Germany, salt is extracted from mineral waters by this process with profit, where evaporation with ordinary fuel would not pay. In such process the water is allowed slowly to trickle through wooden frames about thirty feet high and many feet long, filled with straw and twigs. This framework has no sides, thus affording a thorough circulation of the air, and as the liquid trickles through the frame, enough of the water is evaporated to cause it to reach the bottom trough sufficiently concentrated to justify using heat for the final evaporation.

Another case of spontaneous evaporation, applied commercially, is the evaporation of sea-water practised in Portugal and Spain, where direct solar heat is utilized for evaporation.

In this case the solution is pumped into shallow ponds and allowed to stand exposed to the sun's rays for three or four weeks, when sufficient evaporation will have occurred to start a crystallization of the salts.

Evaporating Apparatus.—The articles essential to evaporation in pharmacy are dishes and stirring rods and the appropriate sources of heat. Other apparatus used in the technic and of advantage in pharmacy, though not essential, are fume closets and hoods, grommets, and the very useful but expensive vacuum apparatus.

Evaporating Dishes.—These are made of porcelain, glass, or platinum, shallow vessels of the appearance shown in Fig. 60. For practical purposes the porcelain dish is generally preferred, being more durable and comparatively inexpensive. Glass evaporating dishes are too fragile for continued use, and are chiefly used in crystallization. Platinum evaporating dishes are used in some chemical operations, their expense precluding general use.

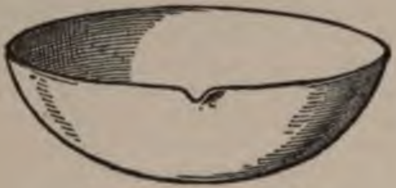

Fig. 60.—Evaporating dish.

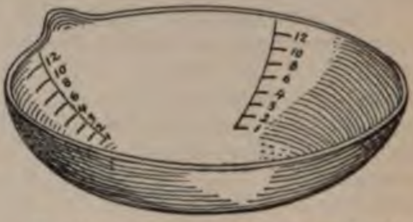

Fig. 61.—Evaporating dish, graduated inside.

In some cases of evaporating directions are given to "reduce" the liquid "to a certain bulk," and for this purpose graduated evaporating dishes have been introduced (Fig. 61).

Instead of same, however, a home-made contrivance answers just as well, and this consists of a rod or cylinder of wood, measuring the volume by marking same on the stick (Fig. 62).

To avoid the necessity for these graduated evaporating dishes the United States Pharmacopœia directs such evaporations to be conducted until the liquid is brought to a definite weight, in which case the evaporating dish is transferred from the source of heat to the scales. Of course, in order to learn the weight of the liquid the weight of the evaporating dish itself, "the tare," must have been previously ascertained. It is a good practice to tare each dish when obtained, and mark the tare in lead-pencil on the outside.

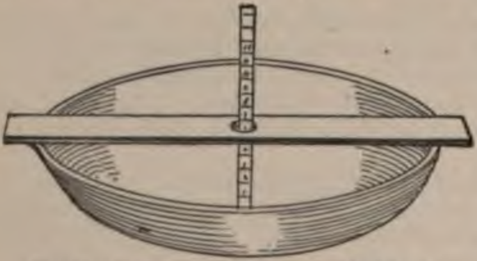

Fig. 62.—Evaporating dish, graduated with stick.

An important point to remember in the use of an evaporating dish is that same should never be heated in direct flame, the source of heat being modified either by use of the wire gauze or by disks of asbestos.

A warm evaporating dish should never be placed directly on a counter. If the counter is of wood, the heat may be sufficient to soften the varnish, and if it is of metal or marble, the rapid chilling of the evaporating dish, through the difference in its temperature and that of the surface of the counter, may cause a fracture of the dish. It should, therefore, be placed on a mat, or, better, on a "*grommet*," the latter consisting of a rubber ring the construction of which is shown in appended sketch (Fig. 63).

Stirrers.—The stirring of an evaporating liquid is a valuable aid to rapid evaporation; hence the use of stirrers. Their construction depends on the uses for which they are intended. Thus, in large operations, such as evaporating infusions of drugs containing no acid, a large tin spoon is as valuable as a stirrer. In other large operations, such as making syrups, a wooden paddle answers. For the more delicate operations of pharmacy and chemistry glass rods are required, which can be obtained in various diameters from chemical apparatus manufacturers in three- or four-foot lengths, and then can be readily broken by scratching with a file and applying pressure on either side of the scratch, thus fracturing same, as shown in Fig. 64.

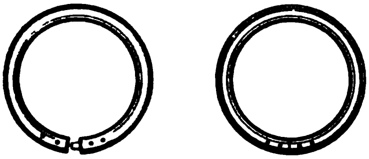
Fig. 63.—Grommet.

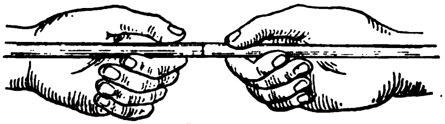
Fig. 64.—Breaking glass rod.

In cutting these stirring rods it is best to make them of such length that about two-thirds will rest within the container for which intended. If more than a third projects over the outside, they are apt to be top heavy. After breaking the rod to the appropriate length, the rough edge should always be smoothed by rotating in a Bunsen flame until slight fusion is effected. If the rough edges are permitted to remain, there is danger of scratching the interior of the evaporating dish.

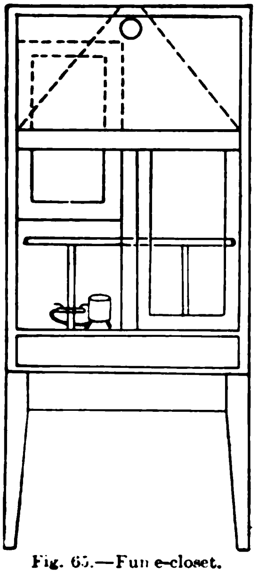
Fig. 65.—Fume-closet.

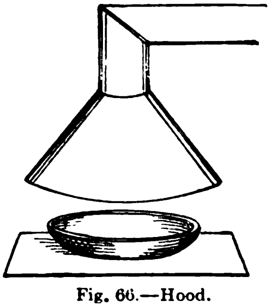
Fig. 66.—Hood.

Fume-closets and Hoods.—Evaporation of a large quantity of liquids, and particularly the evaporation of liquids yielding disagreeable or corrosive vapors, in a closed room is objectionable, and to carry off these vapors fume-closets and hoods have been devised. The principle of these two is the same, both being an inclosed space connected with a flue or chimney, through which there is sufficient current of air to draw off the offensive vapors. The closet is a large piece of furniture constructed of wood and glass, and attached directly to the wall (Fig. 65). For a hood can be utilized appropriate lengths of stovepipe, the lower end of which is arranged around a metallic dome, directly under which is placed the evaporating liquid. Hoods work best if connected with a suction pump (Fig. 66).

Vacuum Apparatus.—The principle of the operation of a vacuum apparatus having been explained, it is necessary here merely to state that many organic substances, when evaporated even at water-bath temperature, will dissociate. Thus, if sugar is evaporated even at the heat of 100°C., the brown substance, molasses, is produced with accompanying vitiation of the finished product. For all such cases vacuum evaporation is desirable, and this is performed in a suitable evaporating utensil, usually heated by the steam coil, and connected with a dome apparatus which, in turn, is connected with an appropriate vacuum pump (Fig. 67). From the illustration it will be seen that the vacuum

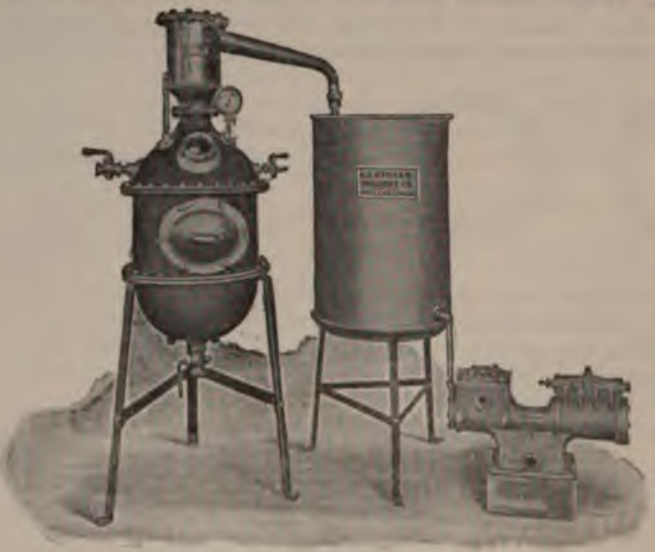

Fig. 67.—Stokes' vacuum still.

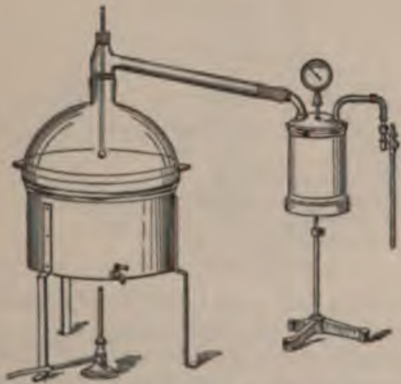

Fig. 68.—Pharmaceutic vacuum pan.

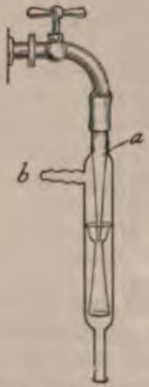

Fig. 69.—Water suction pump: *a*, Water-tube; *b*, air-tube.

Fig. 70.—Manometer.

pan is connected with a worm condenser (p. 97), thus permitting the recovery of the solvent, if it is costly. This is usually the case when vacuum evaporation is employed in pharmaceutical manufacturing, where it is chiefly used in the concentration of alcoholic percolates, such as in making extracts (p. 270). As seen in the illustration, the air is exhausted by means of a pump operated by steam-power. In the technic such evaporating apparatus is largely used, and for pharmaceutic and chemical purposes a small and comparatively inexpensive apparatus of the same character has been devised (Fig. 68).

For removing atmospheric pressure, any form of air-pump can be used, but usually in laboratory work the water suction pump (Fig. 69) is employed. This can be attached to the ordinary hydrant, provided the water pressure is sufficient. In this simple and useful apparatus the rapid flow of the water through a narrow point draws with it the air from the tube and from the connected aspirator, and if the water pressure is sufficient, a vacuum of 17 mm. can be readily obtained. By a vacuum of 17 mm. is meant that the height of a column of mercury supported by the atmosphere is reduced from 760 mm. to 17 mm.; the latter figure therefore, showing a pressure of only $^{17}/_{760}$ of the ordinary atmospheric pressure. The indication of this pressure is accomplished by the instrument called the manometer. Some forms of manometer are delicate apparatus made on the principle of the steam gage, but for chemical work a simple manometer consisting of a bent tube (Fig. 70) filled with mercury, and set up against a scale, answers all purposes.

The simple form of such vacuum evaporating apparatus is that figured in vacuum distillation (p. 103).

DISTILLATION

Distillation is the process of converting a liquid into a gas, and condensing the gas back into a liquid.

Objects.—In distillation we have an admirable method of purifying volatile substances. If such a liquid contains impurities less volatile than itself, the impure product is placed in a still and heated, whereupon the substance desired will distil, leaving the less volatile substance behind. In many cases the foreign matter is water, in which case distillation is of great value in strengthening the product under consideration. This is particularly the case in a separation of alcohol from whisky or other alcoholic liquors, which is always accomplished by distillation. The liquid thus purified by distillation is called a "*distillate.*"

In other words, distillation is evaporation of a liquid and subsequent condensation of its vapor. Evaporation has been described on a preceding page, and here it is necessary to turn attention only to the second part of the process, namely, condensation.

As already learned, to convert a liquid into a vapor means the expenditure of considerable energy, which energy is obtained from a source of heat, this heat being converted into the other form of energy—that necessary to keep the molecules of the gas separate from one another—is no longer indicated by means of the thermometer, and such heat is called "latent." If the converting of the liquid into a vapor means the expenditure of considerable heat, so in the inverse operation of changing the vapor back into a liquid an equal amount of heat is given off. In other words, heat is rendered latent in converting a solid into a liquid or a liquid into a gas, and, in turn, latent heat is rendered sensible by changing gas back to liquid, or liquid back to a solid form. Therefore to condense a vapor back to liquid form the chilling of the vapor is necessary, that is, the latent heat must be absorbed by being brought into contact with a cooling agent. The converting of the vapor back to the liquid form in condensing can be accomplished in many cases by bringing the vapor in contact with chilled water.

The amount of water required can be figured out mathematically, and depends on the temperature of the vapor and the temperature of the water before and after its use as a condensing agent. Thus, 1 kilo of steam at 100°C. will take 23.2 kilos of water at 20°C. for condensation, and the temperature of the water after condensation will be 45°C., or 1 kilo of steam at 100°C. will take 24 kilos of water at 10°C., heating it to 35°C. during condensation.

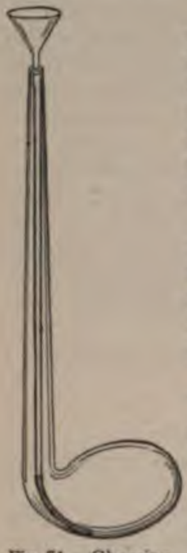
Fig. 71.—Charging plain retort.

The **apparatus** required for distillation consist primarily of a *boiler*, in which the liquid is vaporized, and the *condenser*, in which the vapors are chilled until they are condensed to the liquid form. This combination of boiler and condenser is commonly called the *still*, and the many forms of this apparatus which are in use can be roughly divided into two classes—the alembic form and the retort form.

In the alembic form the condensing apparatus is directly over the boiler, while in the retort form the condensing apparatus is placed on one side of the boiler, thus not directly over the source of heat. The retort form of a still being more commonly used, it will be discussed first.

Retort Still.—So called because the original form of boiler for such operation was the glass instrument called a retort, which consisted of a glass flask with a long and tapering neck, bent at an acute angle. This simple form of retort is inconvenient by reason of the difficulty in filling such a retort, it being, of course, essential to secure a pure distilled product that the neck of the retort through which the distilling vapor passed should be free from impurities.

Therefore, the charging of such a retort must never be done by pouring the liquid down the neck, but the liquid must be introduced into the bowl of the retort by means of a funnel with a long tube connected therewith (Fig. 71).

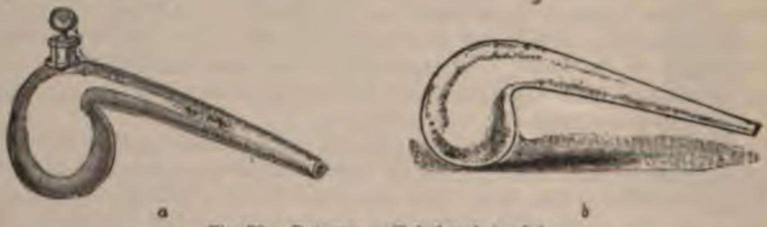

Fig. 72.—Retorts; *a*, Tubulated; *b*, plain.

Of greater convenience is the tubulated retort, the use of which is strongly urged in preference to the plain form. In purchasing such a retort be sure, however, that the tubulure is correctly placed, namely, directly over the bottom of the bowl, for, if the tubulure is placed otherwise, there is danger of spattering the neck of the retort with the impure liquid when it is poured in (Fig. 72).

For the purpose of insuring the cleanliness of the neck of the retort care should be taken to select such having an acute bend. In retorts where the bend is round rather than acute, there is always danger of some of the liquid being drawn over the bend by capillary attraction into the neck of the retort. Retorts formerly had extended use, but at present they are in less demand and have been largely replaced by the more convenient and simple instrument, the distilling flask (Fig. 73), which consists of a chemical flask of required size, provided with a cork stopper through an orifice of which passes a piece of bent glass tubing. In many cases a second hole is bored through the cork for the insertion of a thermometer. Details of fitting the connections will be given later. A more compact form of distilling flask for small operations is shown in the illustration here given (Fig. 75).

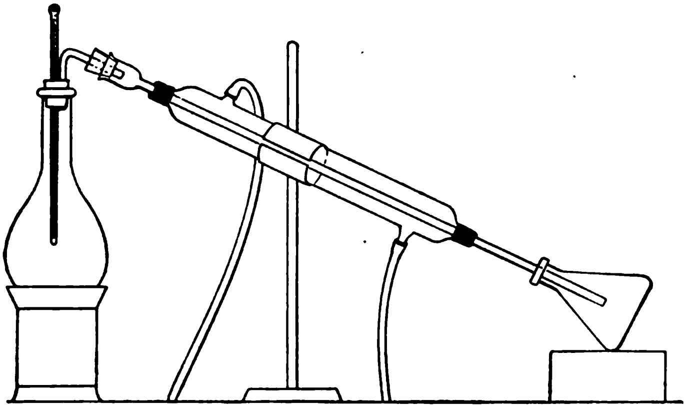

Fig. 73.—Flask distillation.

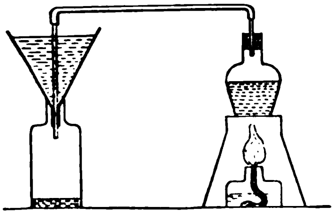

Fig. 74.—A simple distilling apparatus.

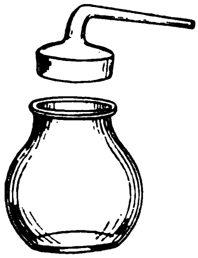

Fig. 75.—Glass-stoppered distilling flask.

Condensers.—The condenser is the part of the apparatus in which the vapors are converted into a liquid, and consists of an appropriate container which can be kept cooled by means of ice or running water.

The simplest form of condenser is a *receiver*, which, in many cases, consists of a chemical flask resting within a basin, in which water or ice can be placed. The more elaborate forms of receivers, the tubulated and quilled, are shown in Fig. 76.

The receiver is the only form of condenser necessary for liquids boiling above 150°C., in which case the temperature of the atmosphere is sufficiently below the temperature of the boiling liquid to permit its use for condensing purposes. In most cases, however, it is usual to have the receiver immersed in water, as mentioned above. In distilling liquids boiling below 150°C., such as water or alcohol, the air is not sufficiently cool to act as a perfect condenser, and in such cases cold water is usually substituted, it being convenient to arrange a continuous stream of water by connecting the condenser with a hydrant. In cases where a hydrant is not convenient, a stream of running water can be maintained by placing the water in a container several feet above the condenser, and maintaining a continuous stream over the condenser by means of the syphon. In such cases of water condensation, preference is usually given to the Liebig condenser.

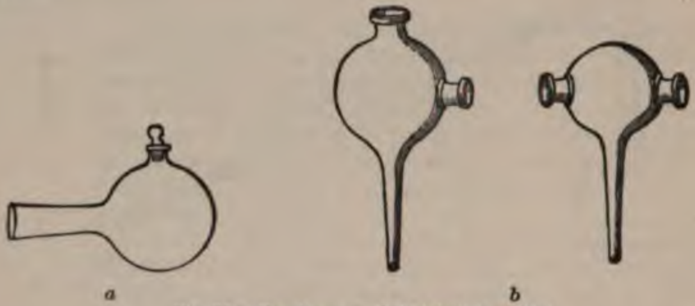

Fig. 76.—Receivers: *a*, Tubulated; *b*, quilled.

Liebig Condenser.—This consists of a long glass tube which is connected with the boiler, be it a retort or flask, thus affording passage to the vapor arising from the boiler. Surrounding this glass tube is a second tube, either of glass or metal, through which passes a stream of cold water (Fig. 77).

In the typical form of Liebig condenser the outer glass tube has soldered thereto ingress and exit tubes, and both ends of the cylinder are tapered so that the joint between the inner glass tubes and the condensing cylinder is made water-tight by means of rubber tubing.

Such condenser, while handsome, is rather fragile, because the projecting ingress and exit tubes are apt to be broken off, with resulting fracture of the glass cylinder. Therefore, of far more practical use is the simple home-made condenser, consisting of a central glass tube passing through two corks, which effectually close the outer cylinder of uniform caliber. Through each of these corks passes an ordinary piece of glass tube, which serves as an entrance and exit tube for the water (Fig. 78).

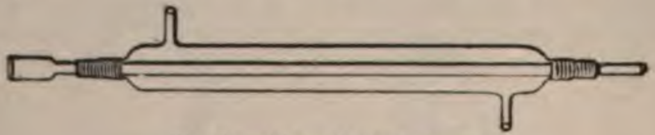

Fig. 77.—All-glass Liebig condenser.

In this case the outer cylinder can be made either of glass or metal, and a very effective form of condenser can be made by using, as the outer cylinder, the ordinary tinned iron plaster box.

Should the condensing tube become dirty, it can be washed with soap and water and scrubbed by passing through the tubes a plug of cotton attached to a stick or rod.

The only objection to the condenser just described is that the condensing tube, in order to be effective, must be of considerable length, say three or four feet, and accordingly occupies considerable space when the apparatus is set up. In large processes of distillation, such as the manufacture of alcohol, a much longer condensing surface is required, and to make an effective straight condenser, taking, say, thirty feet, is hardly to be considered by reason of the space it would necessarily occupy.

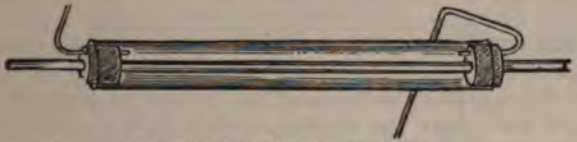
Fig. 78.—Corked Liebig condenser.

This gave rise to a modification which answers the double requirement of occupying small space and of affording a large condensing surface.

The Condensing Worm.—This consists of a tube of glass or metal (usually block tin), twisted into a spiral and fitting into a vessel through which water can circulate freely. Such form of worm is used for all the large processes of distillation, such as obtaining alcohol and alcoholic liquors and distilling volatile oils. The objection to the worm, from the pharmaceutic standpoint, is due to the fact that its spiral form renders a thorough cleaning very difficult.

In technical operations a worm is used continually for the distillation of one substance, in which case a thorough cleaning is rarely needed, and this is accomplished by running water and other appropriate solvent through the tube. A combination of worm and Liebig condenser is shown in Fig. 79, it has value in a well-equipped organic laboratory, but is of little use in pharmacy because of difficulty of cleaning.

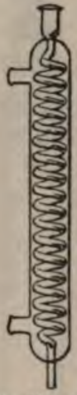
Fig. 79.—Spiral condenser.

Distilling Appliances.—In performing distillation with flask or retort and condenser, the fitting of the apparatus is a matter of considerable skill, and requires appliances not yet mentioned.

Glass tubing is usually needed to complete the connections, and a stock of good tubing should be at the disposal of every pharmacist, and with the manipulation of same he should be thoroughly acquainted. Such tubing comes in lengths of three or four feet, and can be easily broken into required lengths in the same way as glass rods, and, as in the case of glass rods, the edges should always be rounded by holding in a flame.

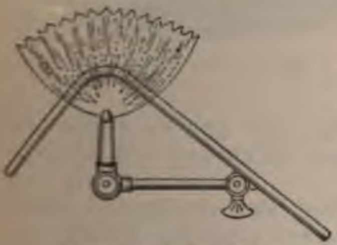
Fig. 80.—Bending tubing.

In bending glass tubing best results are obtained by first grasping one end, holding the tube over a fish-tail flame in such way that the end held by the hand is nearer the flame than is the other end. Rotating in the flame is not necessary, for, when sufficiently softened, the tube bends by its own gravity, and a round, smooth curve is obtained (Fig. 80).

The glass tube bent, the same must be inserted through the cork, which means that the holes must first be bored through the cork. This is done either by a rat-tail file (Fig. 82) or by a cork-borer, a set of hollow brass tubes with lower end sharpened (Fig. 81), and the latter does the work so much more neatly that its use is strongly recommended.

To hold the condenser and the flask in place, we use clamps attached to a *retort stand*, a piece of apparatus of great value in all the operations described in this chapter, consisting, as it does, of support with clamps for condensers and rings for holding dishes during evaporation or percolators or funnels (Fig. 83). In the absence of such a stand the ingenious and economic pharmacist can easily make an appropriate holder for his condenser from a wooden box, as shown in Fig. 84.

In connecting the condenser with the water mains, rubber tubing is essential, and very convenient for regulating the flow of water are the *pinch-cocks* which slip over the tubes and which can be opened or closed as shown in Fig. 85.

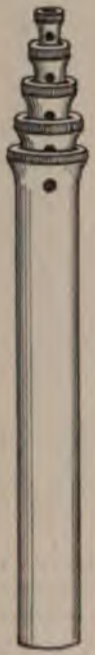
Fig. 81.—Cork-borers (nested).

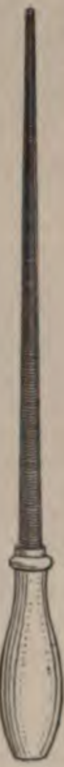
Fig. 82.—Rat-tail file.

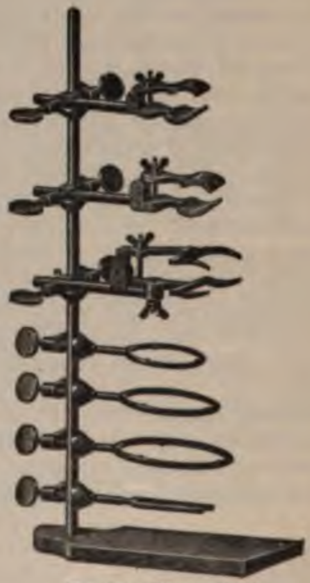
Fig. 83.—Retort stand.

In making the connections between retort and condenser, rubber tubing is equally useful, although in processes requiring careful distillation contact of the vapor with rubber tubing should be avoided as much as possible, in all cases it being advisable to have the glass tube from the retort introduced into the condensing tube (Fig. 86). The neck of most large retorts is usually larger than the opening of the condensing tube, and in such case, in order to avoid recourse to direct rubber connections, *adapters* are used, these consisting of tapering glass tubes which complete the "all-glass" connections between the retort and the condenser. For adapters nothing is better than the neck of a broken retort (Fig. 87).

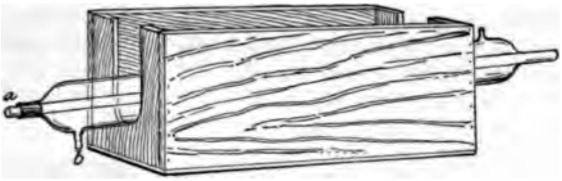

Fig. 84.—Box condenser holder.

In some cases of distillation care must be taken to prevent the pressure of the vapor from producing a fracture of the distilling apparatus, or even explosions, and for such purpose safety tubes or funnels are used, as seen in Fig. 88. Those used in chemistry consist of a bent thistle funnel, in the elbow of which a few globules of mercury are placed, thus producing sufficient pressure to prevent a needless escape of the vapor, but being thrown up into the thistle bulb when the pressure within the flask becomes dangerous.

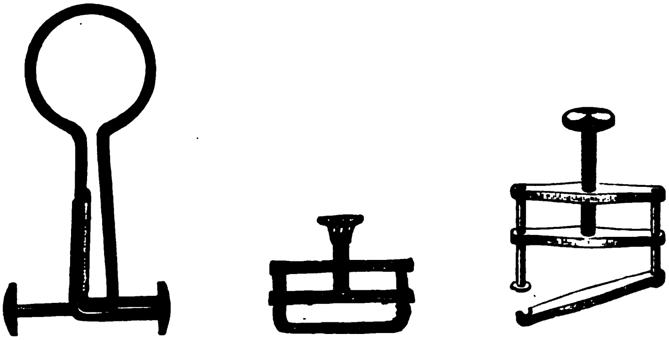

Fig 85.—Pinch-cocks.

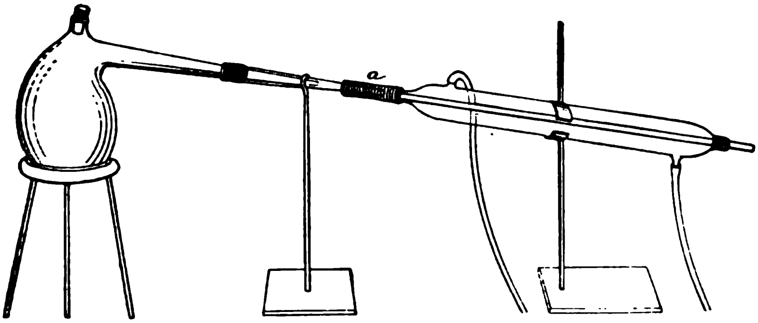

Fig. 86.—Fitting retort to condenser: a, Flaxseed lute

Bumping.—This phenomenon is a disagreeable accompaniment of many cases of distillation occurring in a flask. In some cases the liquid does not boil steadily under application of heat, but at times the ebullition ceases for a few moments, then suddenly resumes, with a force sufficiently explosive to cause a spattering of the liquid, if not a fracture of the flask.

Bumping occurs chiefly with heavy and somewhat viscid liquids, which cause a retention of generated steam until a sufficient quantity has been formed to force its way through the opposing medium.

To eliminate this phenomen, which very frequently spoils a tedious distillation by spattering some of the impure liquid into the condenser, and thence into the distillate, means to distribute the heat uniformly, and the insertion of pieces of pumice-stone, glass, or platinum has been suggested. None of these, however, answers as well as the maintaining of a minute current of steam or air through the distilling liquid.

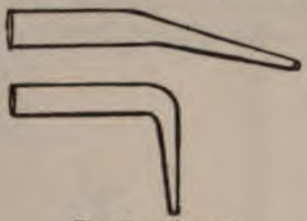
Fig. 87.—Adapters.

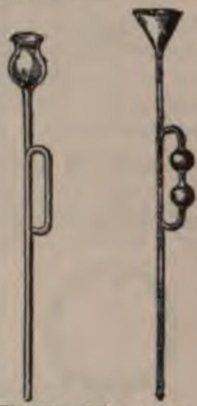
Fig. 88.—Safety tubes.

Alembic still is that form in which the condenser is directly over the boiler, and while the liquid distils more slowly in the alembic than in the retort form, it gives a purer distillate, as there is no danger of any of the liquid being carried over mechanically. A good commercial type of this form of still is the Phœnix condenser (Figs. 90 and 91).

Modifications of Distillation.—*Fractional distillation* is the method used for separating a mixture of several liquids of different boiling-points. Assuming, for example, we have a mixture of ether, boiling-point 35°C., chloroform, boiling-point 61°C., and alcohol, 78°C., it seems easy to separate them by placing in a flask connected with a condenser and having a thermometer inserted in its neck, and gradually applying heat. When the temperature of 37° is attained, the ether should all distil over and be collected. Raising the temperature to 61°, that portion should all distil over and be collected in a separate container, and, lastly, by raising the temperature to 78°, the residue, which should consist entirely of alcohol, should distil over and be collected. However, the process is by no means as simple as this, for the reason that while it is true a liquid does not boil until a certain temperature is attained, the vaporization of that liquid occurs at temperatures other than its boiling-point, and, accordingly, the first distillate we obtain contains alcohol, chloroform, and ether, and likewise the second and third distillates contain some traces of ether, which had not been fully vaporized at the lower boiling-point.

Therefore, in order to carry out the distillation thoroughly, it is necessary to take the three distillates we have obtained and redistil them, and experience has shown that a second repetition of the experiment will finally yield products which are practically chemical entities.

This process of repeated fractional distillation is largely used in chemistry, although scarcely at all in the ordinary pharmaceutic operations. By this means we are able to separate the volatile oils into their many constituents, and the same process is used for the separation and purification of the petroleum products.

Upright Condensation.—In some chemical and pharmaceutic processes it is found necessary to warm the substance for several hours with alcohol. To do this in free contact with air is an expensive undertaking, as alcohol evaporates very freely and would therefore pass into the atmosphere and be lost.

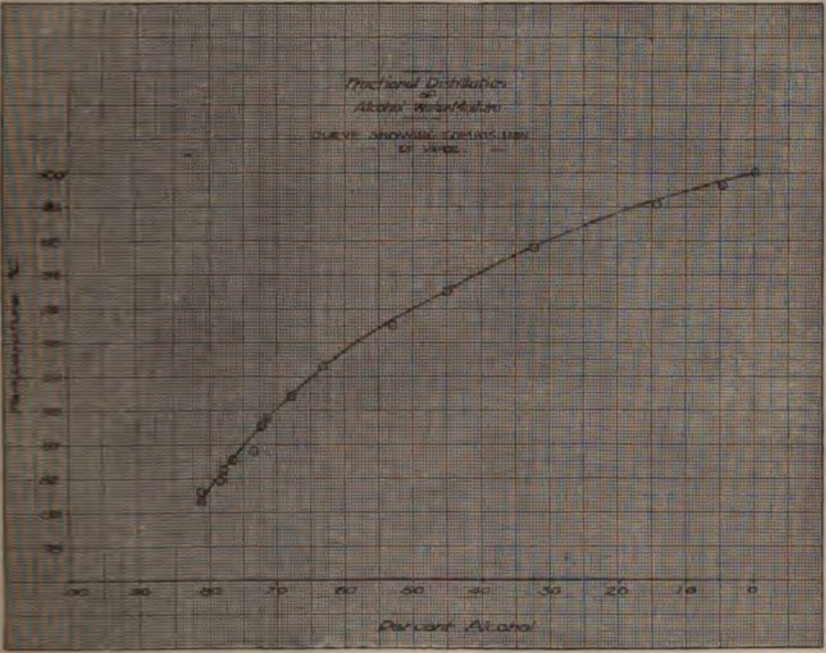

Fig. 89.—Graph of alcohol distillation.

Physical chemists have shown that the problem concerns the tension of the mixed vapor and they have been able to plot out curves showing the successive boiling-points of such mixtures. Fig. 89 shows the "graph" for alcohol and water mixtures. Checking up the dots on or near the curve, we find that when the thermometer in the upper part of the still (not immersed in the liquid) registers 82°, the strength of the alcoholic distillate is 78.5 per cent. that when the temperature is 85° the alcoholic strength is 72.4 per cent.; that when the temperature is 91°, the alcoholic strength is 53 per cent.; that when it is 100°, the alcoholic strength is 0.0 per cent. In the same way the twelve other readings can be readily deduced from the chart.

To permit economy in alcohol and similar valuable liquids, upright condensation has been devised. This consists (Fig. 92) of arranging the condenser in such relation to the flask that, as the vapors of the alcohol rise and are condensed, they are immediately dropped back into the flask, and by this means it is possible to keep alcohol at the boiling-point for weeks at a time without apparent loss. A form of upright condensation, in which the mixture is heated in tin canister provided with a cork, through the hole of which passes a long glass tube, is directed in the official method for making tincture of cantharides.

A compact form of upright condenser is that devised by Soxhlet. This consists of two metallic hemispheres, the inner one communicating with the flask in which the liquid is heated, and the outer one with the water-supply; therefore, corresponding to the inner and outer tube of the Liebig condenser respectively (Fig. 93).

Some processes of distillation, as in the extraction of the volatile principles of drugs, are largely performed by intimately mixing the source of the volatile substance with water contained in the boiler, and heating both together, whereby the water and volatile constituents of the drug are volatilized and pass into the condenser, where they are liquefied and separated, the oil usually being immiscible with water.

Such, for example, is the method whereby oil of peppermint is obtained from the herb, and in all such cases of distillation care must be exercised to prevent the herb from coming in direct contact with the bottom of the vessel, the greater heat of which is apt to cause a partial charring of the organic drug, with subsequent decomposition of same, giving rise to the disagreeable tarry odor called "*empyreuma.*" This decomposition is obviated by preventing the drug from resting on the bottom of the boiler, either by suspending the drug in an appropriate cloth, bag, or sack, or by having a still with a wire basket, such as is shown in the picture of the Remington still (p. 103).

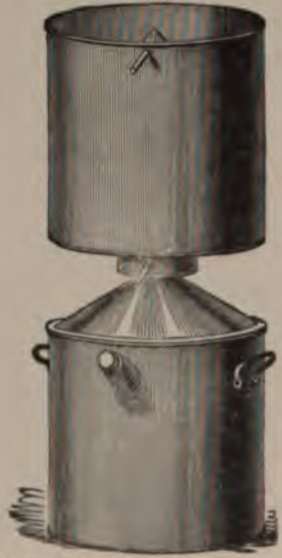

Fig. 90.—Phœnix condenser.

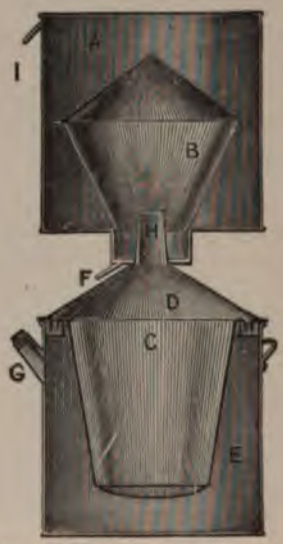

Fig. 91.—Phœnix condenser (outline).

A. Tank for cold water; B, condensing dome; C, boiler; D, connecting dome; E, water-bath; F, distilled water outlet; G, bath-water outlet; H, steam outlet; I, condensing water outlet.

Far better is the protection of the drug accomplished in the process of *steam distillation*, which consists in generating the steam in an appropriate tin can provided with safety tube, and passing the steam thus generated into the flask or can containing the drug, and an appropriate quantity of water (Fig. 94).

Through this the steam passes, carrying the volatile constituents of the herb into the condenser, where both become fluid.

Destructive Distillation.—In other pharmaceutic processes the decomposed products of the substances heated are desired. In some cases the substance is placed in a large iron retort and heated strongly, whereby the substance is decomposed and the volatile decomposition products pass over and are condensed by appropriate means. Such condensation is used in the destructive distillation of wood, whereby we obtain the valuable commercial products, wood alcohol, acetone, and acetic acid. (See p. 586.)

Vacuum Distillation.—As mentioned on p. 92, evaporation is facilitated by removing air-pressure from vessel where the evaporation occurs, and at that place details for large operations of that character were given. In the chemical laboratory small operations of evaporation and condensation can be readily accomplished in the apparatus shown in Fig. 95, which, it will be seen, consists of two distilling flasks connected by air-tight rubber corks. One of the flasks acts as the boiler, while the other serves as condenser, and to the exit-tube of the latter is fitted the outer tubing connecting with the vacuum pump (p. 93).

In the neck of the flask acting as the boiler is fitted a rubber cork, through the orifice of which passes a glass tube drawn to a capillary point. The outer end of the tube is fitted with a piece of rubber tubing which is opened and closed by means of a pinch-cock. The object of this tube is to permit egress of sufficient air to prevent bumping; and if the temperature of the distillation is to be observed, the thermometer is inserted in the tube.

The condenser is chilled by a stream of running water, while the boiler is heated by means of a Bunsen burner, with or without water-bath.

Special Stills.—As mentioned above, the word "still" is usually applied in the technic to a piece of apparatus, made of metal, consisting of boiler and condenser, and the varieties of these special stills are so numerous that space forbids more than mention of a few of the typical forms.

One of the most popular is the old-fashioned still with condensing worm, and, besides this, mention may be made of *Phœnix pharmaceutic condenser* (Fig. 90), which is of the alembic form; the *Curtman still* (Fig. 96), which is a combination of the alembic and retort form, and the *Remington still*, in which the condenser occurs in a modified form of the Liebig condenser (Fig. 97).

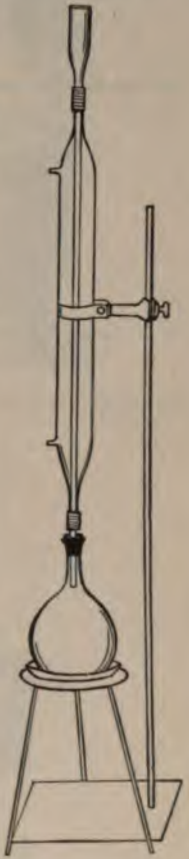
Fig. 92.—Invert condenser.

A noteworthy feature in the Remington still is the arrangement of the condenser with seven parallel tubes placed in the same outer cylinder, on a principle akin to the tubular boiler. This modification gives a very extensive condensing surface in a comparatively compact form (as in a condensing worm), and possesses the advantage over the condensing worm that all tubes are straight, hence can be easily cleaned. This still is provided with a wire basket in which the drug desired to be distilled

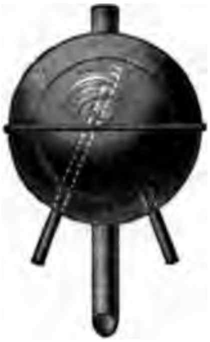

Fig. 93.—Soxhlet's invert condenser.

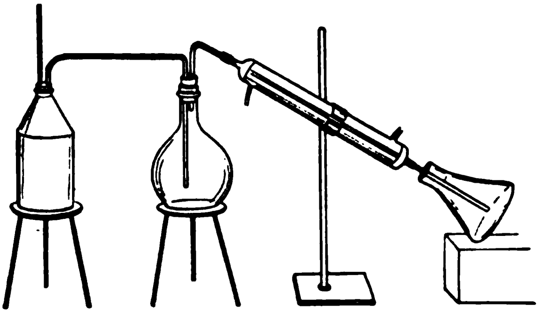

Fig. 94.—Steam distillation.

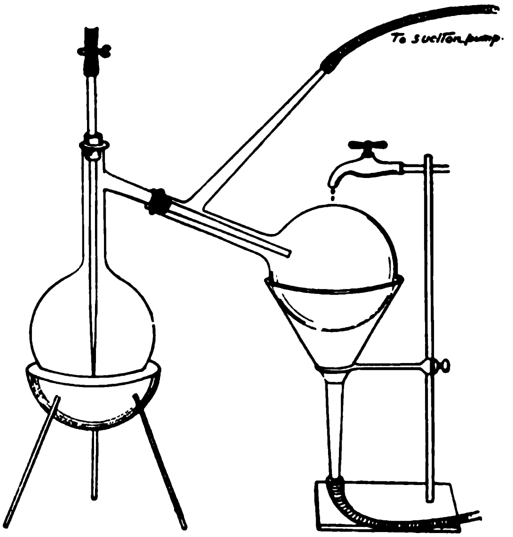

Fig. 95.—Vacuum distillation.

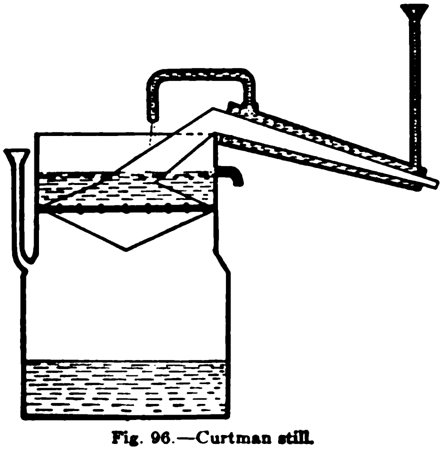

Fig. 96.—Curtman still.

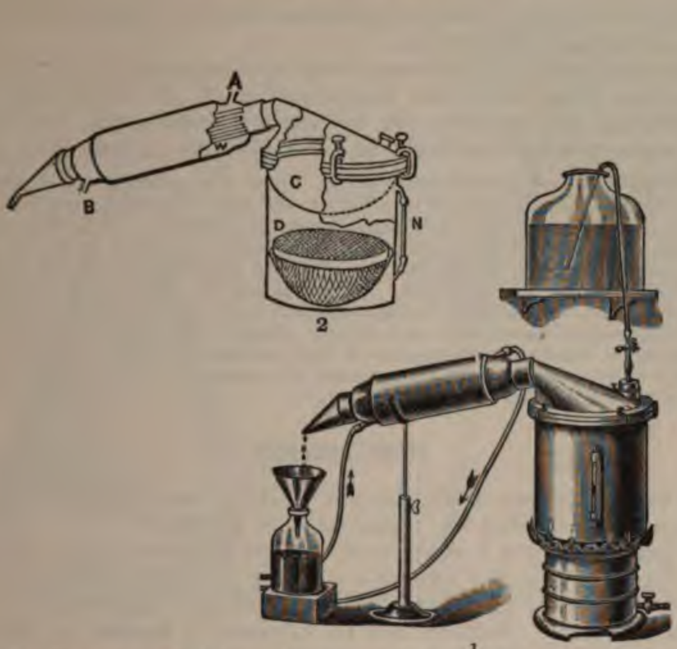

Fig. 97.—The Remington still: 1, Apparatus set up ready for use; 2, section showing condenser and wire basket. A, Condensing water outlet; B, condensing water inlet; C, boiler; D, wire basket; N, water gage; W, condensing tubes.

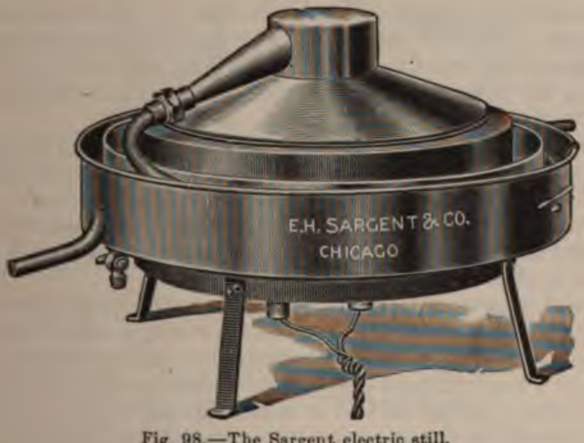

Fig 98.—The Sargent electric still.

can be placed, thereby preventing contact with the bottom of the boiler and the consequent empyreuma.

Stokes has devised an automatic wall apparatus that distils ½ gallon of water per hour with the consumption of 10 cubic feet of gas while Sargent has constructed an electric water-still distilling 4.5 liters of water per hour with the use of a 110-volt current (Fig. 98).

The *Lloyd still* and concentrator works upon the principle that evaporation occurs rationally from the surface of a liquid, and that it is unnecessary to keep the contents of a still or an evaporator heated during the process. If the heat be applied to the surface of a liquid, the menstruum is instantly separated from the dissolved matters, which, dropping down into the still, are immediately cooled, and remain cool until the end of the operation. By automatically conducting a percolate to the heated surface, the distillate being conducted back upon the drug in the percolator, continuous distillation and percolation result. The application of the heat is instantaneous, whether the amount of drug worked be large or small. By this method the most delicate organic structures are preserved in solutions where a prolonged boiling would dissociate and destroy.

SUBLIMATION

This is the process of distilling a solid; of converting the solid into a vapor, and condensing the vapor back to a solid.

We generally term a solid that can be converted into a vapor "a volatile solid," but it is a question whether the latter phrase should not be limited to a solid which volatilizes at ordinary temperatures, such as iodine or camphor. Sulphur can be sublimed if heated to 448°C.; but it can scarcely be considered as a volatile substance.

A comparison of the three stages of the process shows how closely akin is the process to distillation:

Distillation	Liquid–gas–liquid.
Sublimation	Solid–gas–solid.

The object of sublimation, like distillation, is to obtain a volatile drug in a purer form. Sublimation is also one method of obtaining crystals.

As the apparatus employed in distillation was one of two types, so in sublimation the operation is carried on in apparatus of either the alembic or the retort type.

If the vapors are condensed directly over the vaporizing substance, if the condenser is but little cooler than the temperature of vaporization, the sublimate will form in a solid mass—a *cake sublimate*. If, on the other hand, the condensing space is on one side, hence considerably cooler than the vessel in which the substance is vaporized, we get a fine powder —a *powdered sublimate.*

No artificial means of refrigeration are needed in sublimation, the air being sufficiently cool to condense the vapor into a solid form.

Several of the official sublimed substances can spontaneously change from a solid to a gas, without assuming the intermediate form of a liquid. This can be noticed in any bottle in which camphor has been kept, where handsome crystals, products of spontaneous sublimation, can be found in the upper part of the bottle.

Benzoic acid is another volatile official that sublimes to crystals. Not so, however, with the shining flakes of resublimed iodine, which are sometimes wrongly called crystals. Iodine is amorphous, as we will learn when we take up crystallization.

Apparatus.—Since in sublimation the condensation is usually effected at the temperature of the air, the apparatus used in the process is very

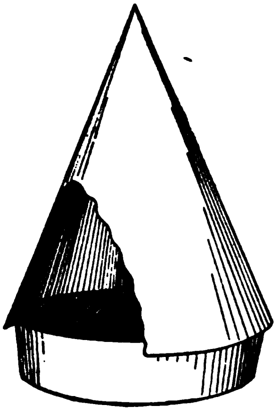

Fig. 99.—Subliming benzoic acid.

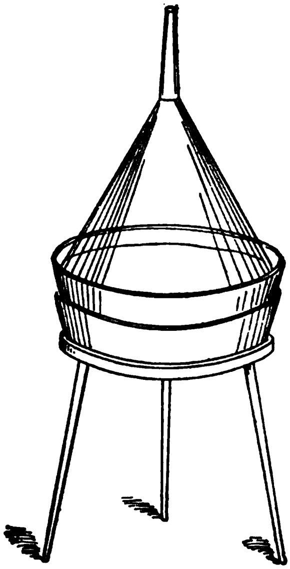

Fig. 100.—Subliming camphor (small quantities).

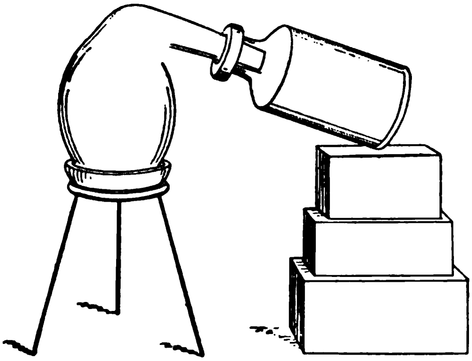

Fig. 101.—Sublimation of sulphur in glass retort.

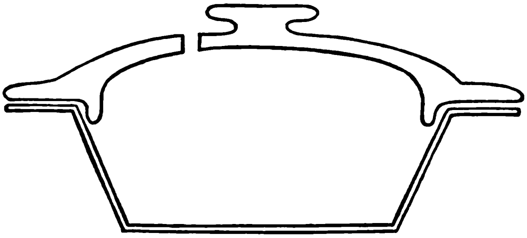

Fig. 102.—Subliming vessel for ammonium chloride.

simple, but similar to distillation in possessing the boiler part and the condensing part.

In small operations the alembic subliming apparatus consists of a dish covered with a cornucopeia of paper, or with a glass funnel terminating with a wide-mouthed bottle (Figs. 99 and 100), while when powdered sublimates are desired, an ordinary retort is used as the boiler, and a wide-mouthed bottle as condenser (Fig. 101).

In the sublimation of large quantities of chemicals the apparatus is usually of cast iron, the condenser consisting either of the cast-iron dome over the retort, or a well-cooled room into which the neck of the retort projects. Apparatus of the first kind (Fig. 102) is used for the sublimation of such cake sublimates as ammonium chloride; whereas the apparatus of the second kind is used for the sublimation of sulphur and the like, where a powder is desired.

DESICCATION

Desiccation is a *process of removing water from a substance at moderate temperature*, thus differing from exsiccation, which means removing the water from a substance at high temperatures.

Desiccation is one of the most commonly applied processes in domestic economy. For example, it would be perfectly correct to call the drying of a wet cloth by exposing it to air and sunlight "desiccation."

Objects.—Desiccation is employed to aid in the preservation of the drug; to reduce the bulk of same; and to facilitate comminution.

That the drying of a substance aids its preservation by preventing the formation of mold is a fact well established, it being generally known that when most organic substances are allowed to remain in a permanently moist condition, moldiness and ultimate decomposition result.

It is a fact worthy of the pharmacist's attention, inasmuch as it is a dictum that it is only a damp substance which becomes moldy, and, therefore, mold can be prevented by keeping the substance in a dry place.

Bourquelot has shown that simpler desiccation of plants does not wholly prevent deterioration, since drying at ordinary temperatures does not destroy the oxidizing enzymes. (See Chap. LI.) These can be destroyed only by submitting the plant to higher heat and preferably to heated alcohol vapors.

Another phase of desiccation is the keeping dry of those drugs like ergot which are prone to absorb moisture from the air. The fifth edition of the German Pharmacopœia directs that such drugs be kept in vessels over freshly burnt lime and several types of drug closets and canisters have been devised for this purpose.

That desiccation reduces the bulk of a substance can be shown in the drying of fresh herbs. Fresh herbs contain from 70 to 80 per cent. moisture, therefore the dry drug will weigh only about one-fifth of the frese drug, and will occupy a much smaller space. The presence of moisture in a fresh drug renders it practically impossible to reduce same to powder, and if attempted by pounding the fresh drug in the mortar, a pulp results; hence it is given as a third object of desiccation that the process facilitates comminution.

Desiccation is not merely the drying of the fresh herbs, but means the removal of moisture from any drug; for example, if a chemical, like potassium acetate, absorbs moisture and becomes liquefied, there is no need of throwing away the liquid mass, since by applying a gentle heat to the substance, the moisture will be eliminated and the dry chemical obtained.

In the same way, in making such pharmaceuticals as pills or lozenges, the freshly finished compound will be moist, and before putting same away, they should be freed from this moisture by desiccation. If such pills or lozenges are put away before completely dry, they will become moldy.

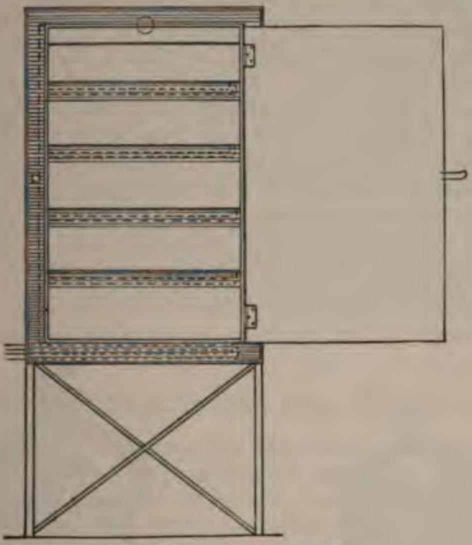
Fig. 103.—Drying closet.

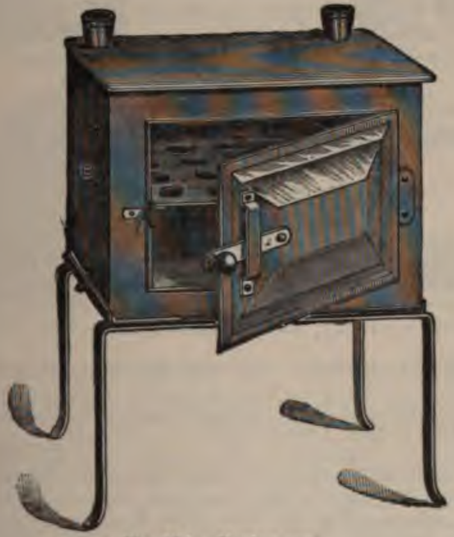
Fig. 104.—Drying oven.

Apparatus used in desiccation is as varied as the different characteristics of the subjects to be desiccated. Thus in drying the herbs no apparatus is needed other than stout gunny bags, which are suspended in places having free access to air. In the smaller desiccations performed in laboratories several forms of apparatus are used. Among these mention may be made of *drying closets* (Fig. 103), which consist of a cupboard, similar to a fume-closet, and, like it, having access to a flue, but arranged with a source of heat, such as a radiator, underneath. For still smaller operations *drying ovens* are used, these being heated by means of the Bunsen burner, and usually jacketed, so that a water-bath heat may be maintained if desired (Fig. 104). Such ovens can be maintained at a uniform temperature by use of special appliances called *thermostats*.

To prevent a substance which has been desiccated from absorbing moisture from the air, recourse is had to *desiccators*, these usually consisting of a glass vessel provided with a ground-glass cover, the joints being made air-tight by tallow or petrolatum, the vessel being so arranged as to contain in an appropriate space sulphuric acid or calcium chloride, both of which substances absorb water with great avidity, thus rendering the air within the container practically water free.

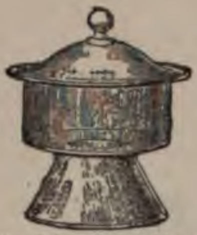

Fig. 105.—Glass desiccator.

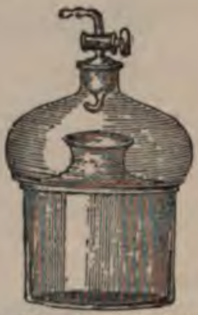

Fig. 106.—Hempel's desiccator.

Of the two forms of desiccators illustrated in Figs. 105 and 106, the Hempel desiccator is arranged to permit a vacuum.

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CHAPTER VI

COMMINUTION

This is the process of reducing a substance to finer particles, and, according to the fineness into which the particles are divided, we subdivide the subject into the branches cutting, slicing, chopping, rasping, grating, bruising, grinding, pulverizing, and triturating.

To obtain the substance in still finer form than that yielded by trituration, the processes of levigation and elutriation are used.

These several objects will be considered in regular order, with mention of apparatus used in each case.

Objects.—The chief object of comminution is to present the drug in a form in which it is more susceptible to solution. In fact, with the exception of comminution for the purpose of making the so-called dusting-powders, all processes of comminution used in pharmacy are made with the intention of facilitating solution of the drug or its active principles.

VARIETIES OF COMMINUTION AND APPARATUS USED

Cutting, slicing, and **chopping** are familiar operations, rarely used in pharmacy, except for the preparation of drugs for the more complete processes of comminution. Cutting and slicing can, of course, be performed with any appropriate knife and chopping with any sharp instrument, such as a hatchet or cleaver, and in place of these familiar instruments, the best apparatus in pharmacy for the purpose is the herb-cutter (**Fig. 107**). This can be used in cutting practically all drugs, and even for vanilla-beans, prior to making tincture therefrom. However, for the cutting of vanillia-beans, nothing is better than to take about a dozen beans, wind them tightly with a piece of stout twine, and slice them down with a sharp carving-knife.

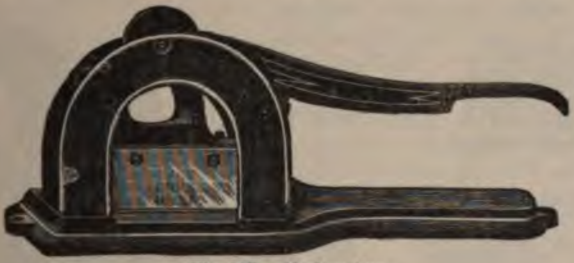

Fig. 107.—Herb-cutter.

Rasping and **grating** are not used very much in pharmacy, about the only drug which is convenient to rasp being guaiac wood, while grating is limited to the comminution of the small portions of nutmeg or lemon-peel, a nutmeg-grater being an inexpensive and convenient apparatus to have at a prescription counter.

Contusion or **bruising** is performed in a mortar, and for this special purpose the old-fashioned iron mortar is very useful. By means of the instrument almost any drug can be reduced to powder of almost any fineness, but the process is so tedious that it has largely been replaced by grinding in a mill.

Other objections to the iron mortar are that pounding therein is a very noisy process, and a continuance of this pounding in a large mortar is apt to jar the building where the operation is conducted, hence such an apparatus should be used only on a firm foundation, and if on an upper floor, the mortar should be placed on a rafter and, if possible, over a supporting pillar.

Wooden mortars were formerly in considerable use, and at present are sometimes used in the bruising of acid drugs, such as beating up a tamarind pulp preparatory to making confection of senna, while huge marble mortars, which formerly enjoyed considerable popularity, have now almost completely fallen into disuse. Mortars used for contusion, the familiar form of which are seen in appended cut (Fig. 108), must not be confounded with the smaller mortars used in process of trituration at the counter.

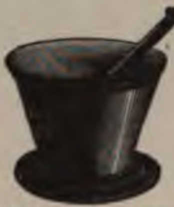

Fig. 108.—Iron mortar.

Grinding and Pulverizing.—Grinding is the process of reducing substances to moderately coarse powders. Pulverization is a term usually applied to grinding to a still finer powder. In both cases the operation is carried on in special apparatus called mills.

A discussion of mills, as of stills, means mention of a vast variety of apparatus adapted for the various requirements of the trade, for example, in a thorough discussion of the subject, mention should be made of flour-mills and mills for other large technical processes. Even in the consideration of the strictly pharmaceutic operation of drug-grinding, almost as large a number of mills could be discussed, and picking from this array the most typical forms, it is necessary to discuss the following, but with a brief mention of their principle of action, leaving the cuts to convey the main characteristics.

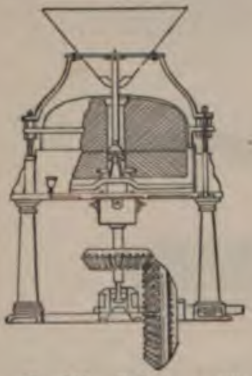

Fig. 109.—Buhrstone mill.

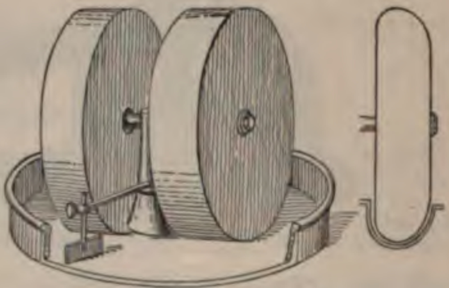

Fig. 110.—Chaser mill.

Buhrstone Mill.—This is the ordinary form of mill, and is made of two stone corrugated plates which rotate on each other. On the rotating surface of the two are made grooves which act on each other, and on the drug interposed, in a manner somewhat similar to the blades of a scissors, clipping the drug to pieces at the same time that the weight of a stone crushed the drug to powder. Such form of mill is seen in the typical flour-mill (Fig. 109).

Roller-mill.—This consists of two large rollers of steel or iron, which revolve on each other and can, by means of suitable mechanism, be made to approach and become remote from each other. Such mill works entirely from the dead weight of the roller, and is used for the powdering of greasy or soft substances.

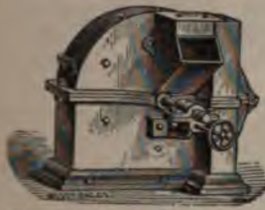

Fig. 111.—Mead disintegrator.

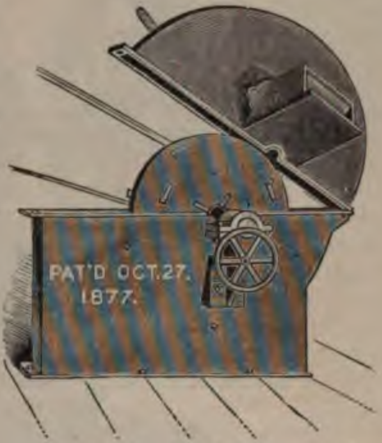

Fig. 112.—Mead disintegrator (open).

Chasers consist of two movable rollers rotating on a central axis on a steel base (Fig. 110). Such a chaser mill is used in the making of chocolate paste and the like.

Barrel or *cannon-ball mills* consist of barrels made of oak or steel, containing iron spheres about the size of cannon-balls, the barrel being arranged to rotate upon an axis, and when this is done, the cannon-balls roll to and fro with sufficient force to powder the drug contained in the barrel. The advantage possessed by a barrel-mill is that the process of pulverization is made with but little loss, because none of the dust escapes. Its objection, however, is the intolerable noise of the rolling cannon-balls.

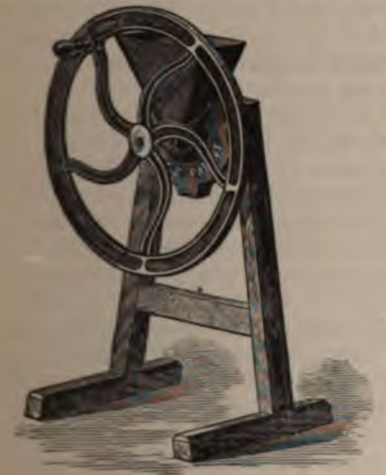

Fig. 113.—Swift mill.

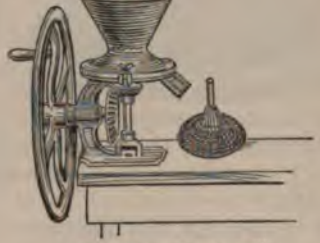

Fig. 114.—Hance mill.

Mead's disintegrator is the most efficient type of the modern power drug-mill, and can best be understood by studying the cuts (Figs. 103 and 112). As seen therein, it consists of a steel disk having on the outer edges a series of steel projections. This disk rotates in a case the upper edge of which consist of corrugated steel, against which the projections in the disk come almost into contact. The unique principle of the mill is the fact that it performs its work not by reason of its weight, but because of the enormous velocity at which the disk rotates, the drug placed in the mill being thrown up by the disk and its projections against the steel corrugations with a force somewhat akin to a cyclone and is so literally torn to shreds.

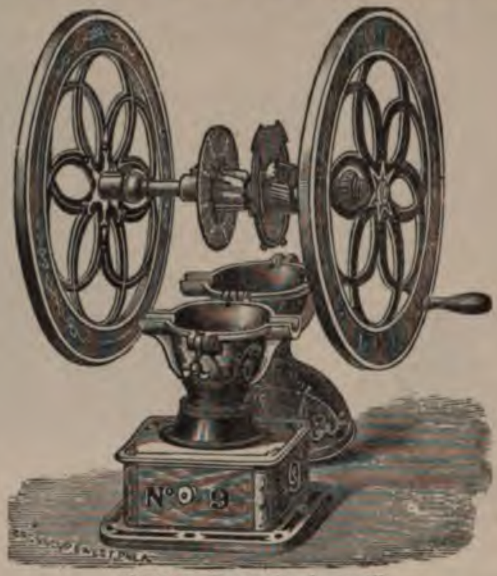

Fig 115.—Enterprise drug-mill.

All the mills above mtionened operate entirely by steam power, and are, therefore, beyond the province of the retail pharmacy, hence of more importance to pharmacists are the mills now to be discussed.

Fig. 116.—Triturating mortar.

Hand Power Mills.—Of the many varieties of hand mills, three types can be considered: Those in which the drug is crushed between two vertical grinding surfaces, those in which the grinding surfaces are horizontal, and those in which the grinding surfaces are conic.

An example of the first type is found in the old-style Swift mill; the second type is shown in the Hance mill, and the third type is represented by the Enterprise mill, all of which are shown in the cuts (Figs. 113, 114, and 115).

Of these mills, the most serviceable is the conic variety, and in selecting a mill it is highly advisable to choose one in which the plates are easily removed for cleaning. By means of a drug mill, a substance can be readily reduced to powder provided suitable care is taken by the operator, it being a good rule to first grind the substance coarsely, then return it to the mill, bringing the plates closer by means of the screws intended for that purpose, grind the drug again, and possibly repeat the operation with the screws still tighter. In rotating the plate by means of the crank or wheel, a uniform and steady motion should be maintained, far better results being obtained by a slow persistent motion than by rapid and spasmodic efforts. Under no circumstances should the mill be worked so rapidly as to overheat the plates. With proper treatment a drug-mill should last a lifetime.

In grinding and sifting irritating and poisonous drugs, such as soap bark, the mouth and nostrils of the operator should be protected by covering them with a moistened towel.

Trituration is the process of reducing a substance to a finer powder than is usually obtained by grinding in a mill, and is generally accomplished by placing a drug in a mortar and acting on same by the rotary action of the pestle. The apparatus used in trituration is the pestle and mortar aided by the spatula, and for trituration the pestle and mortar of wedgewood ware should be of the design shown in the appended cut (Fig. 116), while porcelain mortars and pestles are usually of the shape shown in Fig. 116. For triturating powders which become electrified and hence sticky, like salol or neural, porcelain mortars are preferable to wedgewood. Such mortars are constructed of porcelain, wedgewood, or glass, and for the trituration of very hard substances agate mortars are sometimes used.

The pestle accompanying the regulation wedgewood mortar has usually a wooden handle which is put into the wedgewood base in a very crude way, usually by pouring a mixture of rosin and wax into the socket and placing the handle in while the mixture is still warm. Usually a pestle so fastened is very inconvenient, as the rosin and wax will chip off and fall into the substance being triturated. If it is used in trituration of warm ointments, the wax is apt to soften, and if employed in mixtures containing alcohol, the alcohol is apt to dissolve the resin.

It is a good rule to fasten the pestle handle securely as soon as purchased, and this is easily done by removing the handle from the base by gentle warmth, cleaning the socket free from the resinous matter, and then pouring into the socket a thin mixture of plaster-of-Paris with water, inserting the handle immediately, and allowing it to stand until the mixture has completely set. A handle so fastened usually remains attached to the base.

As there is, however, some danger of the chipping of the plaster, a cement consisting of glycerin and oxide of lead (litharge) made into a paste has been recommended.

A wedgewood mortar after continual use becomes grimy and cannot be cleaned by the simple application of soap and water. To thoroughly cleanse such mortar, powder a few crystals of potassium dichromate in the same and rub to a thin paste with sufficient concentrated sulphuric acid; smear same over the mortar outside and in. When the paste is washed off, the wedgewood will be found perfectly clean.

Spatulas.—The object of the spatula in trituration is to scrape the triturated powder from the sides of the mortar, and for this purpose a small spatula convenient to carry in the vest pocket is most convenient. Of the two forms of spatula shown in illustrations, the nickel-plated form is the most modern and most satisfactory, and every pharmacist should carry one as his personal property (Figs. 117 and 118).

Triturates.—Aside from the general term, trituration, as applied to reducing drugs to fine powder, a class of preparations called "triturates" have been introduced. These are of homeopathic origin and consist of the medicine intimately mixed with sugar of milk. The Pharmacopœia recognizes as this class of triturates preparations containing 10 per cent. of the active ingredient rubbed up with 90 per cent. sugar of milk. (See Triturate of Elaterin, p. 295.)

Sifting is the process of separating finer portions of comminuted drugs from the coarser particles by use of a sieve.

Fig. 117.—Cocoa-handle spatula.

The grinding of a drug, no matter how carefully carried on, will not in itself produce an absolutely uniform powder, the more easily pulverulent portions of the drug being ground more finely than the denser portions. In order to insure a uniform powder, therefore, it is necessary to sift same through sieves, which consist of mesh work either of horsehair or metal wire stretched around a suitable holder (Fig. 119).

Fig. 118.—Nickel-plated spatula.

The sieve can be made with meshes of equal size, and for sifting drugs, sieves with twenty, thirty, forty, sixty, and eighty meshes to a linear inch are usually employed, the finished sieve being accordingly numbered 20, 30, 40, 60, and 80 respectively. Sieves are not uniform even when thus numbered unless each manufacturer uses strands of wire of same caliber.

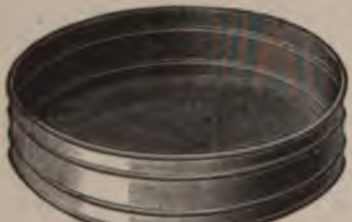

Fig. 119.—Brass sieve.

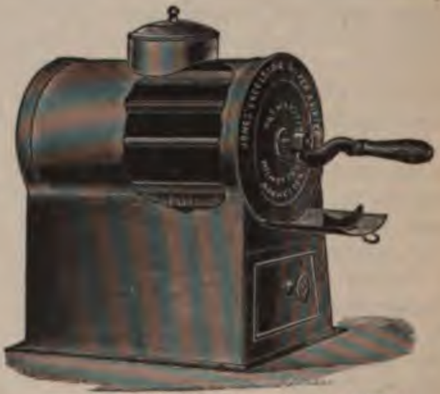

Fig. 120.—Excelsior mixer and sifter.

In Germany and other countries of Europe the numbering of the sieve is different from the English and American, it being based on the number of meshes to the centimeter. As an inch is equal to 2.5 cm., the conversion of the German number to the American is not difficult, each unit of the German sieve being equal to 2.5 units of the American sieve. Thus a No. 15 German is equal to a No. 40 American (exactly 37½): while a No. 20 German equals a No. 50 American.

In using a sieve, the ground drug is thrown therein and the particles permitted to fall through the meshes by gently tapping the sieve with a spatula handle or the knuckle, particular emphasis being laid by pharmaceutic writers against forcing the powder through the sieve by rubbing same with the hand. It is imperative that all portions of the same drug should be reduced to a uniform powder, hence we should not merely use the first portion that passes through, leaving the coarser particles for a subsequent grinding, but we should take a certain quantity of the drug, grind same with the mill, and sift, repeating the operation until the entire quantity has been passed through, except possibly a small amount of fibrous débris. When all the drug has thus been passed through the sieve, the powder is thoroughly mixed with the spatula, and only then can we say that we have completely powdered the entire drug.

Powdered drugs are given the same number as the sieve through which they pass; thus a No. 20 powder means a drug passed through a No. 20 sieve.

The finest sieve in ordinary use is the No. 80, and if the substance is desired to a powder finer than eighty, it is passed through bolting-cloth, which consists of a cloth with exact meshes made of silk thread. The finer grades of flour are thus sifted through bolting-cloth.

When considerable material is to be sifted the use of a special mixing appliance operated either by hand or other power is advisable, one of the best varieties of such an apparatus being the Excelsior mixer and sifter (Fig. 120).

Dusting powders can be mixed and sifted by pouring them into a bag made of bolting-cloth fitted into the neck of half-gallon salt-mouth bottle. The stopper is then placed into the bottle and after shaking the sifted powder will be found at the bottom of the jar.

Levigation is the process of reducing a powder to still finer particles than can be attained through trituration, and is accomplished by placing a substance on an appropriate slab, moistening with a few drops of alcohol, and smearing same over the slab by means of an instrument known as the muller (Figs. 121 and 122.) As shown in cut, the correct way of using the muller is by rotating the same in a circular motion, as if drawing the figure 8. If the slab and muller are composed of porphyry, the process is called *porphyrization*.

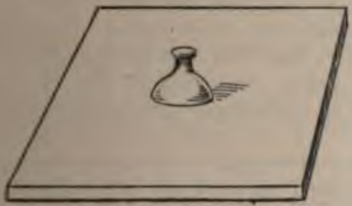

Fig. 121.—Slab and muller.

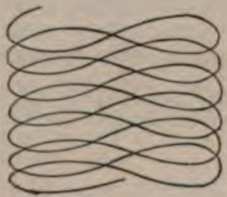

Fig. 122.—Movement of muller.

Elutriation is a crude process of separating coarser from finer particles by suspension in water, hence is sometimes called "water-sifting." It is used only in separating insoluble substances, and is limited to a few cases, such as the separation of chalk from the grit with which it is associated when mined. The freshly mined chalk is coarsely ground, mixed with water to a thin paste, and then thrown into a tank containing water, with the result that the gritty quartz will be washed out and subside, while the less heavy chalk remains for a time suspended in the liquid. After a few minutes the liquid is drawn from the tank into another through a faucet, placed some distance above the bottom of the vessel, and there is allowed to stand until the suspended chalk has separated, whereupon the clear liquid is drawn off and the pasty chalk is obtained almost free from grit. In commerce this chalk paste is usually marketed in the form of cones, and these are produced by the process known as trochiscation.

Trochiscation.—By placing the paste in a wooden vessel shaped like a funnel, and by giving the apparatus sharp raps, the paste drops upon a porous surface, such as a slab of chalk or of earthenware, where it dries in cones, an expert workman being able to make practically all the cones the same size.

Pulverization by Intervention.—There are some substances which are almost impossible to reduce to powder by trituration or other methods of comminution already discussed. Among these the best known example is camphor, which, when pounded with a pestle, becomes a pliable mass. If, however, to the camphor a few drops of alcohol or chloroform be added, it can be powdered without difficulty. This method of reducing a substance to powder by means of another substance is called pulverization by intervention. Camphor powdered with alcohol is apt to cake on standing and this can be obviated by adding to same a minute quantity of colorless petrolatum.

Other examples of pulverization by intervention are the powdering of gold-foil trituration with potassium sulphate, the potassium sulphate being removed after trituration by treatment of the powder with water. Tin can be powdered by pouring the molten metal into prepared chalk and shaking until thoroughly cold, the prepared chalk being separated from the powdered tin by treatment with diluted acids. Phosphorus can be powdered by simply melting it in solution of salt and shaking same until cold.

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CHAPTER VII

SOLUTION, LOTION, DECANTATION, COLATION, AND FILTRATION

SOLUTION

At various times in the history of pharmacy, definitions of the term "solution" have been set forth which can hardly be considered modern views of the subject. Illustrated by examples, this important topic is not difficult to understand.

When a small amount of common salt is shaken up with water the salt quickly disappears and a perfectly homogenous mixture is obtained, which has a salty taste, but in which no particles of salt can be detected, even under the highest power microscope. Even on long standing the salt does not settle out of the water, nor can the salt be removed by filtration of the mixture. However, on evaporating off the water, the salt is left behind in its original form. If, on the other hand, a little chalk is shaken up with water, a milky mixture is obtained in which the particles can be readily seen. and can be separated from the water by settling or by filtration.

In the first case, the salt is taken up or dissolved by the water forming a true solution; in the latter case, the chalk is merely suspended in the water. Between the limits of *true solution* and *suspension* lies the region of *colloid solution* which is discussed in detail on p. 565.

A *solution* may be defined as a homogeneous mixture of two or more substances, which (mixture) can vary in composition continuously within certain limits. The latter part of this definition serves to distinguish solutions from chemical compounds. The latter are of definite and invariable composition, whereas the composition of a solution of salt in water may vary within wide limits.

Although there are several classes of solutions arranged, according to the physical states of their components, in pharmacy we are chiefly concerned with solutions of gases, liquids and solids in liquids.

That part of a solution which is present in largest proportion is usually called the *solvent*, and the substance taken up by the solvent is termed the *dissolved substance* or *solute*.

When some substances, principally acids, bases and salts are dissolved in water, their molecules undergo subdivision into particles called "ions." For instance, nitric acid (HNO_3) ionizes in water altogether into positively charged hydrogen particles (H^+ ions) and negatively charged nitrate groups (NO_3^- ions). In ammonium hydroxide (NH_4OH) solution only 2 per cent. of the molecules of the base ionize or dissociate into NH_4^+ ions and HO^- ions, while the other 98 per cent. remain as NH_4OH undissociated molecules. All substances do not ionize and all liquids are not as good ionizing agents as is water.

Solvent.—In order to dissolve a substance a solvent is required, and the character of different solvents varies greatly, investigation showing that practically all physical combinations, such as the making of solders, fusing of alloys, and the like, follow the same rules as does the ordinary solution. Thus, at present, alloys, such, for example, as brass, are considered solutions of the metals of which they are composed.

Pharmaceutically, however, by a solvent is meant a liquid in which the substance is made to disappear and lose its identity.

Of the solvents used in pharmacy, *water* is preëminently the most valuable, as in it dissolve most inorganic chemicals, and such organics as sugars, gums, and glucosides.

Alcohol dissolves resinous drugs, volatile oils, etc.

Glycerin is an excellent solvent, dissolving the water-soluble substances and in larger quantities, but its stickiness precludes its general use.

Acids are used as solvents in some cases, although usually the acid effects a chemical change in the nature of the dissolved substance.

Alkalis are valuable solvents for some substances, as albuminous matter, waxes, starches, and resins, but they, like the acids, usually make chemical changes in the dissolved substances.

Chloroform and *ether* and *petroleum ether* (or *benzin*, U.S.P.) are solvents for resins, oils, and fats, though their use is somewhat limited.

Carbon disulphide is used for dissolving rubber, while for solution of gutta-percha, chloroform answers.

Of late, in chemical work and in manufacturing industries a large number of organic substances are used as solvents either replacing or in combination with grain alcohol. Among these may be cited *wood alcohol, acetone acetic ether*, "*banana oil*" and the various chlorides of ethane. These are discussed in Part IV.

Solubility.—By this term is meant how much of a substance dissolves in a given solvent. This can be expressed as in the present pharmacopœia as the number of mils of solvent in which one gramme of the substance dissolves; in parts by weight of the solvent used to dissolve 1 part of the substance; or by stating how many parts of the substance will dissolve in 100 parts of the solvent. The range of solubility is practically limitless, some substances in much less than their own weight of the solvent, whereas other substances require many times the weight of the solvent. Thus, silver bromide requires one to two million times its weight of water for solution, while potassium iodide dissolves in seven-tenths its own weight of water. When a substance is so slightly soluble as silver bromide, we usually term it insoluble, although practically every substance does dissolve in minute amounts, as in the case of the chemical just mentioned.

To memorize the individual solubilities of all the officials is practically impossible, although the student should know in a general way whether a body dissolves in water or is insoluble, and, moreover, he should be acquainted with the approximate water solubilities of such well-known chemicals as potassium bromide, potassium iodide, and potassium chlorate.

Regarding general solubilities in water, the following information relative to inorganic salts is useful, especially in considering prescriptions:

SOLUBLE.	INSOLUBLE.
All acetates.	Carbonates, except those of the alkalis.
All nitrates.	Phosphates, except those of the alkalis.
Sulphates, except barium, strontium, lead, silver.	
All sodium salts.	
Potassium salts, except bitartrate.	
Chlorides, except silver and mercurous.	

This table is of barest outline, and refers only to well-known medical substances. For instance, there are a few insoluble sodium salts, but they are not worth consideration in pharmacy. Then remember that the term "soluble" is purely relative. One gramme of potassium iodide is soluble in 0.7 mil of water at 25°C., calcium sulphate, on the other hand, requires 410 parts of water at 15°C. to dissolve it; yet both are classed as "soluble" in above table. Then in the table many substances are missing. For instance, no specific mention is made of copper and zinc salts, or of the silicates, or of a host of other bodies. These omissions are due to the fact that no classification of the substances as to the solubility can be made. Some zinc salts are soluble, some are insoluble; hence they are omitted.

In the present pharmacopœia is found a monograph on solubility estimations (Part II, p. 599).

Simple and Chemical Solutions.—Thanks to the investigations of Arrhenius and Ostwald, the former popular distinction between simple and chemical solutions has become almost obsolete, Arrhenius showing that when the chemical dissolves in water, it immediately dissociates into two or more portions, called "ions," and, in fact, in exactly the same way as some substances separate when under the influence of electricity. In the old method of reasoning a solution of Glauber salt, Na_2SO_4, in water was a simple solution, but if the same salt solution was produced by mixing a solution of sodium hydroxide with dilute sulphuric acid, because a chemical action occurred during the process of solution, this latter solution of sodium sulphate was a chemical solution.

The modern view is that both solutions are identical, consisting as they do of ions of sodium and ions of the SO_4 group; hence in the modern discussion of solution the terms "simple" and "chemical" are eliminated.

During the past fifteen years, Jones and his pupils have worked out what he calls "the solvate theory of solutions." This supplements the ionic theory by pointing out that in solutions the ions and some of the molecules combine with more or less of the solvent.

In the pharmaceutic discussion of the solutions of the United States Pharmacopœia it is convenient to classify same into those made by simply dissolving the solution in water, which solutions are called "galenics," and those in the manufacture of which by the pharmacist a chemical change occurs. In this sense the term simple and chemical solutions are still applied, without, however, any intention to intimate that any marked difference exists between the same compound made by simple solution and that made by chemical action.

Conditions of Solution.—In order to facilitate solution it is advisable to pulverize the substance which is to be dissolved, the *advantages of pulverization* being best illustrated by a homely simile.

Imagine a closed book of 500 pages as a lump or crystal of matter. Imagine this exposed to the action of a solvent. This solvent can only attack front, back, and four edges—a surface scarcely equal to that of three leaves. Now imagine that book taken all apart, and its 500 pages spread flat on the floor, and see what an enormous increase in surface. In the same way a great increase is produced in the surface exposed to the action of a solvent when a crystal is reduced to powder.

After powdering the substance and mixing it with the solvent, solution can be facilitated by *agitating* the mixture of the substance and the solvent, and this, because, when we suggest that a solution is a minute subdivision of the substance affecting the very molecules which permeate the molecules of the solvent, it is plain to be seen that in order completely to mix these molecules, agitation is necessary just as some form of agitation aids in the mixing of solids.

Among the conditions of solution the *character of the solvent* has considerable influence, and it is, of course, self-evident that it is useless to attempt a solution of a substance in a solvent which does not affect it. In the same way care must be had in mixing solutions not to add to the liquid another liquid which is apt to precipitate the dissolved substance, even though that liquid is freely miscible with the solvent that has been employed. Thus, alcohol and water dissolve in each other, but if in the water is dissolved a substance which will not dissolve in alcohol, such, for example, as gum arabic, the addition of more than traces of alcohol will result in the precipitation of the gum from the solution.

In the same way, if we have an alcoholic solution of a resinous substance and add water to it, the water will mix with the alcohol, but in the process of solution of the two fluids the resin, which is insoluble in water, is precipitated.

Temperature is a decided factor in influencing solution. Usually a high degree of heat facilitates solution, although not in a definite ratio. Thus one gramme of potassium chlorate will dissolve in 11.5 mils of water at 25°C., while one gramme of the same salt will dissolve in 1.8 mils of water at 100°C. This is not always true, however, some substances being more soluble in cold water than in hot.

Thus one gramme of lime will dissolve in 840 mils water at 25°C., while it takes 1740 mils of water at 100°C. to dissolve the same quantity.

An interesting case of temperature variation in solution is found in sodium sulphate (p. 443).

Heat aids solution in rendering molecular subdivisions easier. A body, in fusing, changes from a solid to a liquid, simply because the heat changes the condition of the molecules from fixed rigidity to the mobility characteristic of liquids. This is supposed to be caused by the influence of heat in lessening the cohesive force of the molecules of the substance—by pushing the molecules farther apart. In the case of solution, the molecules of dissolving substance becoming separated by diffusion among the molecules of the solvent, the separation—the pushing apart of the molecules—is greatly facilitated by the application of heat, and that its aid in overcoming cohesion is usually enlisted in solution is shown by the fact that, when a substance is dissolved at normal temperatures, it usually takes up so much heat away from the solvent that the liquid becomes cold. This is especially to be noticed dissolving potassium iodide in water, and freezing mixtures are usually devised on this principle. However, bear in mind that all solids do not chill the solvent on dissolving. For instance, when calcium chloride is dissolved in water, the temperature of the solution is raised considerably. This, however, is supposed to be due to a chemical combination with water, as is also assumed to be the case when sulphuric acid or alcohol is mixed with water. Likewise when sodium iodide dissolves in water with production of heat.

Method of Solution.—The ordinary method of dissolving a substance is, as suggested just above, by reducing the substance to a comparatively fine powder in a mortar, then adding the solvent, and triturating until solution is accomplished, and finally filtering the finished solution by passing through a pledget of cotton placed in an appropriately sized funnel. The careful pharmacist, in preparing solutions on prescriptions, should always observe this rule, as the chemicals used are likely to contain minute traces of insoluble impurities, such as fragments of cork from the container, or possibly traces of soot, and to dispense a solution any way other than absolutely clear does not enhance a pharmacist's reputation. In a case of a very soluble salt, such as potassium iodide, the powdering and subsequent trituration in the mortar are not necessary, in such case the solution being quickly effected by throwing the crystals into the flask designed to hold the finished prescription, adding the water, shaking until solution results. In all such cases the rule of filtration through cotton should be rigidly adhered to, it being a simple matter to pour the liquid from the flask into a graduate and then filter into the bottle.

Percentage Solutions.—The method of calculating the quantity of a chemical required in making a solution of a certain percentage strength is discussed on p. 64.

Circulatory Solution.—Some substances, such as gum arabic and sugar, dissolve comparatively slowly, and in such cases recourse is had to that method of solution known as circulatory solution. In this process the substance is tied in a piece of cloth and suspended just below the surface of the solvent. The liquid in contact with the drug becomes impregnated with the substance, and, being of greater density than the water, sinks to the bottom of the container, giving place to a fresh supply of water, which in turn becomes denser and sinks. In this way a constant downward current of dissolved substance and an upward stream of displaced water produces a circulatory motion of the liquid in the container, hence the name, "circulatory solution."

Saturated solution is one which contains all of a certain substance that the solvent will hold in a solution, and the quantity of a drug in such a saturated solution is, of course, dependent on the relative solubility of the drug. Thus, a solution of lime containing in 100 grammes only 16 centigrammes of calcium hydroxide is a saturated solution, even as is a solution of potassium iodide, 100 grammes of which contain about 56 grammes of potassium iodide. In other words, the term saturated means the limit of solubility rather than the comparative denseness of solution. An interesting point connected with saturated solution is that a saturated solution of one substance may act as an admirable solvent of another; in other words, in a saturated solution, the solvent powers of that liquid are exhausted only as far as that one substance is concerned, but can be exerted in effecting solution of another substance. Thus a saturated solution of potassium iodide not merely dissolves iodine, but also much more of that chemical than will water alone. In the same way a saturated solution of potassium nitrate will freely dissolve copper sulphate, and this scheme has been used for removing copper impurities from large quantities of potassium nitrate.

Supersaturated Solution.—Under certain conditions, a solvent sometimes takes up and holds more of a salt than is indicated by the solubility of that salt.

This is particularly the case when the salt is treated with water of a temperature greater than normal. As already mentioned, hot water will usually dissolve more of a salt than will cold water, and such solution, on standing, usually deposits the amount of salt in excess of the quantity soluble at ordinary temperatures.

A solution of this kind, holding more of the salt than is normally dissolved, is said to be a supersaturated solution, and in some cases such a supersaturated solution will remain liquid without depositing the excess until violently agitated. Such is particularly striking, as shown in the case of sodium sulphate (p. 443).

Colloidal Solutions are now extensively used in pharmacy. These are discussed on p. 154.

Volume Changes in Solution.—In effecting solution between a certain volume of a chemical and a certain volume of its solvent, the resulting solution usually occupies less space than do the two ingredients. In other words, contraction of volume occurs in effecting solution. By this, of course, reference is not made to the fact of the solvent occupying the interstices or air-spaces found in a certain volume of a crude chemical, but what is meant is the actual volume of the solvent itself independent of air-spaces. Thus sugar (specific gravity, 1.336) has a specific volume of 0.748, and 85 grammes of sugar, therefore, would occupy the space of 63.6 mils. These 85 grammes of sugar, dissolved in 48 mils of water, made 100 mils of syrup, showing a contraction of 11.6 mils in the process. In the same way dried alum dissolved in water contracts, as does the well-known mixture of alcohol and water in preparing diluted alcohol.

The latter case of the contraction of alcohol and water in preparing diluted alcohol is sufficiently marked to be worthy of attention by the operator, as was shown by an incident coming to the author's attention, in which a pharmacist, in preparing forty gallons of dilute alcohol for a customer, mixed twenty gallons of alcohol and twenty gallons of water, bottled same without measuring, and was much grieved on receiving complaint from the customer that the quantity was several quarts short.

It is said that 50 volumes of ethyl alcohol and 50 volumes of water make 94.35

volumes of diluted alcohol while 50 volumes of methyl alcohol and 50 volumes of water make 98.5 volumes of fluid. Mendeljeff stated that alcohol and water exhibited the maximum contraction when 45.88 per cent. alcohol was prepared and that this showed the formation of a compound consisting of one molecule of ethyl hydroxide and three molecules of water.

Estimation of Solubility.—Reference has been made in a preceding paragraph to the solubility of a solid in water and other solvents. This is done in several ways, the usual method being by weighing a certain quantity of the solid in a tared bottle, adding a certain quantity of water at a given temperature, usually 25°C., shaking until assured of a saturated solution, then carefully transferring the liquid to a quick-acting tared filter and then weighing the solid residue. In this way we learn the amount of the solid which has been dissolved, and the solubility of the solid can be easily estimated on the basis of the solubility of one gramme of the solid; thus, if the experiment shows that one gramme of salt dissolves in three grammes of water, then the solubility is put down as one part in three of water. This method, however, is not exactly accurate, inasmuch as during filtration a certain amount of the solvent volatilizes, therefore leaving a greater residue than that actually soluble. A more accurate way is to take a given quantity of the solution, evaporate same to dryness, and from this estimate the solubility of the solid. In the latter case, however, the contraction of a solid in the solvent must be known, and this factor used in the estimation of the solubility. For simple pharmaceutic purposes a rough estimate of the solubility can be easily obtained by adding the substance to the liquid until no more is taken up. Thus if to 100 mils of water at normal temperature a solid is added in 5-gramme lots, the solubility of the salt can be estimated within 5 per cent., and to attain absolutely accurate results it is only necessary to repeat the experiment by dissolving in the water the amount of salt within 5 grammes of supersaturation, and then add the rest of the salt in half-gramme lots until no more is taken up.

For very accurate estimation of solubility recourse is had to the lysimeter of Dr. Rice, while a good method of determining the solubility of alkaloids by use of volumetric solutions has been suggested by Hatcher. Attention has been called to the fact that in order to avoid supersaturation in estimating solubility the mixture of the solid and its solvent should be thoroughly agitated by means of a mechanical stirrer during the process of solution.

STERILIZATION

This important method of preserving medicinal substances and of rendering surgical appliances aseptic has now stepped from the confines of medicine into the field of pharmacy and the modern pharmacist must stand ready to prepare sterile products on demand. The call for aseptic dressings is now largely filled by special manufacturers; so the prescriptionist is chiefly called upon to furnish sterile solutions.

Realizing this need, both U.S.P. IX and N.F. IV contain comprehensive monographs on sterilization that should be carefully read by all students.

Summarized, the destruction or removal of bacteria or their spores is usually accomplished by submitting the substance to the action of heated air or steam. Glass or metallic containers are best sterilized by heating from 160° to 170° for two hours. Medicinal solutions not injured by high temperatures are heated in a current of steam for one hour if the steam is at 100°C.; for fifteen to twenty minutes if it is at

115° to 120°. In the former case a steam sterilizer is used; in the latter case, an *autoclave* has to be employed.

If the solution (say, of alkaloids) is decomposed by the action of heat, approximate sterility may be attained by filtration through a porcelain (Berkefeld) filter, into containers which have been sterilized by steam, or by sterilizing all apparatus and containers employed in making and storing the solution and by dissolving the substance in sterilized distilled water (p. 368). If glycerin is the solvent, it may be sterilized by heating in a current of steam; while oil is sterilized by heating in a suitable oven to 120°.

In stoppering sterilized solutions, sterile rubber stoppers must be employed.

Cotton, bandages, gauzes and other surgical dressings may be sterilized either by heating with steam at 115° in an autoclave or by dry heat at 160° to 170° in an oven. Such sterilized dressings must be kept aseptic by storing in sterile glass containers or by wrapping in sterilized parchment paper.

The more elaborate monograph given in the National Formulary outlines sterilization at low temperature or *pasteurization* (which means heating the material between 60° and 70° for one-half to one hour each day on six successive days) and sterilization by means of chemical agents (subjecting apparatus and material to the action of such antiseptics as alcohol, formaldehyde, phenol, etc.)

AMPULS

The preservation of sterile products in sealed glass tubes was first tried by Limousin in 1886 and since 1908, the practice has become very popular in medicine; so much so that if the prescriptionist does not learn to meet the demand, the large manufacturer will take from him even the preparation of simple solutions. The following suggestions are therefore offered and further details can be gotten from the articles cited in the bibliography at the end of the chapter.

Ampuls are sealed glass tubes containing medicaments, either solid or liquid furnished to the physician or the patient in a sterile condition and frequently furnished single hypodermic doses.

The Ampul.—The glass tubes, usually purchased from special glass manufacturers are made from a special type of glass known as No. 16 III, which is less alkaline than the average glass. Nitardy shows that satisfactory ampuls can be made from ordinary test-tubes, but in passing it might be said that such ampuls are almost certain to contain enough free alkali to precipitate alkaloidal solutions. Ampuls are sometimes made with the open end flaring like a funnel, in order to facilitate filling. (Fig. 123.)

Filling Ampuls.—Many filling devices, some very complicated and some quite simple, have been devised, the aim being to run the fluid down through the narrow neck as expeditiously as possible, a trick that is really not easy, since some provision should be made for exit of air as the fluid flows in. Some fill from a burette to the tip of which is attached a hypodermic needle; some use the modern type of large-sized graduated all-glass hypodermic syringe which can be easily sterilized; while the best appliance is one in which by a system of valves and air-tight containers the ampuls can be exhausted of air before the fluid is introduced into the container. Because of the partial vacuum in this container and in the ampuls found therein the fluid immediately fills the ampuls so soon as air is permitted to enter the apparatus. Such type of apparatus, made of inexpensive materials, has been devised by Lascoff. (See Fig. 124.)

Sealing the Ampul.—This is accomplished by bringing the tip of the filled and cleaned ampul into a small but hot flame of a blast lamp.

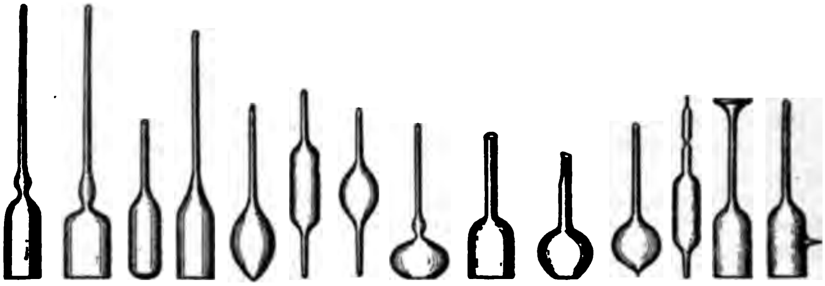


Fig. 123.—Various shapes of ampuls.

This operation is not as simple as first appears, but, like everything else, practice will bring the knack. In large factories, for instance, such sealing is done by young girls.

Sterilization.—As mentioned above, the product in the ampul should reach the physician in a sterilized condition. This is sometimes accomplished by having the ampuls, the fluid and the filler all in sterile condition at the moment of filling, but the usual procedure is to sterilize the sealed ampul by heating in an appropriate oven. The oven must of course be provided with a thermometer and care taken that the temperature be not allowed to rise above that which the content of the ampul will bear without decomposition. It is manifestly very important that the oven be kept closed from the beginning of the operation until after the sterilization is complete and the oven again cool, to guard against the risk of injury from ampuls which may explode while being heated.

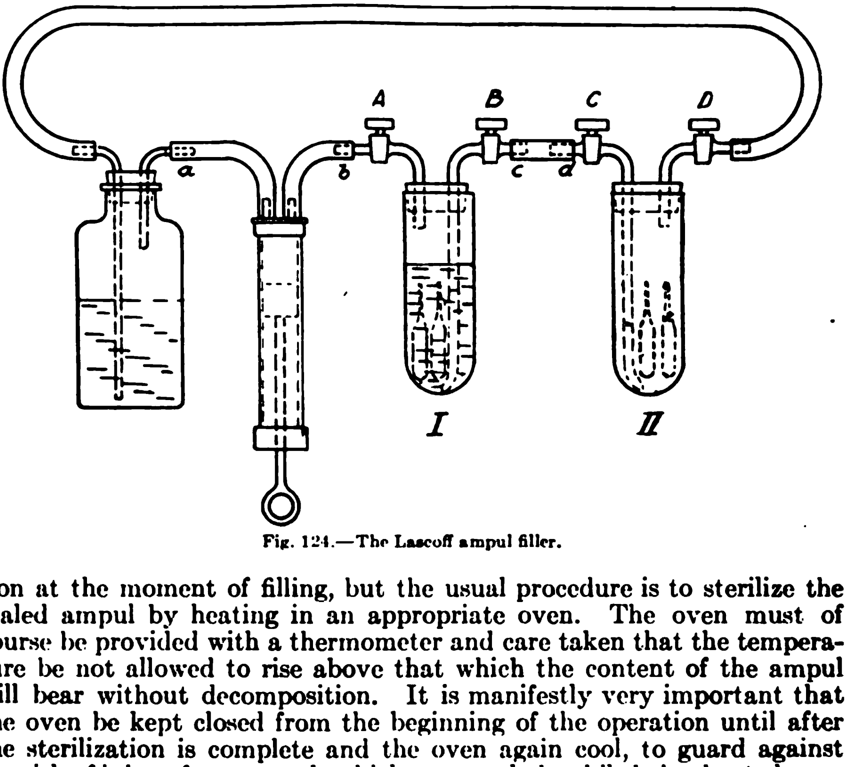


Fig. 124.—The Lascoff ampul filler.

Gaseous Solution.—While physically a solution of gas in a liquid differs but slightly from the solution of either a solid or a liquid, the mode of preparing a gaseous solution differs sufficiently from the solution of either a solid or a liquid to justify a special heading. In effecting the solution of a gas in water when the gas is freshly generated or supplied from a storage tank (in which form liquid carbon dioxide is used largely for charging soda fountains), it is first washed by passing through water and then conducting it through a tube reaching almost to the bottom of the container holding the liquid, and to insure solution it is best that the container be long and narrow. When the soluble gas is run into the liquid, it is noted at first that the large bubbles emerging from the end of the tube are absorbed before they reach the top of the liquid; as the solution becomes more and more saturated it is found that the bubbles are less dissolved, until finally it can be noted that the size of the bubbles on emerging from the top of the liquid is about the same as when emerging from the end of the tube. When this stage is reached, it is always advisable to remove the container with the liquid and shake vigorously, again pass gas through, and if it is found by this means that no more gas is being dissolved, the operation is complete.

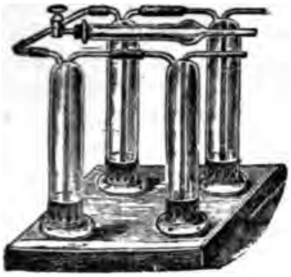


Fig. 125.—Apparatus for drying gases.

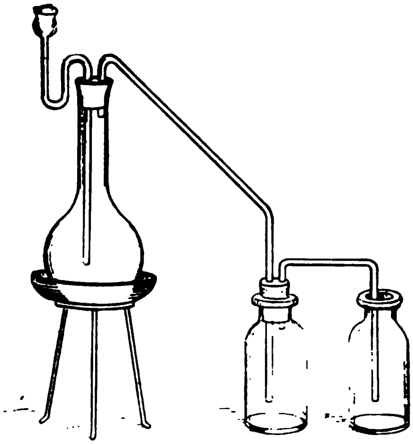


Fig. 126.—Gaseous solution.

A simple test of saturation of a liquid with a gas is by observing the behavior of the solution after agitation. Place the hand over the mouth of the container, and if, after each agitation and attempted removal of the hand from the mouth of the bottle, a suction is felt, it is a strong evidence that the solution is not saturated. If, on removing the hand, a pressure of the escaping gas is observed, it is rather a fair indication of complete saturation.

In some cases, before making a solution of the gas, it is essential that same be dried, that is, freed from water vapor, in which case, instead of running such gas through water, it is passed through concentrated sulphuric acid, calcium chloride, or other substance having great affinity for water, contained in appropriate flasks (Fig. 125). There are some gases which cannot be dried with calcium chloride nor sulphuric acid, such, for example, as ammonia, gas and in such cases the gas can be fairly well dried by passing it through a bottle containing absorbent cotton. An illustration showing gaseous solution is appended (Fig. 126).

LOTION

Lotion is derived from the Latin "lotio" (to wash), and means the removal of soluble impurities from insoluble substances by washing same with water or other appropriate liquid. Thus, in the last stage of purifying precipitated calcium carbonate, the precipitate contained on the filter is washed with water, while in making washed sulphur the sublimed sulphur is washed with a mixture of water and ammonia water.

Apparatus used in lotion consists of funnel with a filter-paper, or straining rack containing an appropriate strainer. (See Colation.) On this filter or strainer is thrown the substance mixed with the wash liquid, the latter, of course, passing through the strainer, the meshes of which hold back the insoluble matter. Upon the precipitate contained on the strainer, water or other wash liquid is poured until all of the soluble impurities have been removed, as can be ascertained by appropriate tests.

When only a small quantity of washing is required, the liquid is spurted upon the filter from a Spritz bottle, which consists of an ordinary pint chemical flask provided with a two-holed rubber stopper, through one hole of which passes a glass tube extending almost to the bottom of the flask, and above the cork bent at an acute angle and with the outside end drawn to a tapering point. Through the other hole is passed a shorter piece of glass tubing bent at an angle of 120–140 degrees. The water is removed from the Spritz bottle by blowing through the shorter piece of glass tube, when the increased pressure of air inside the flask will cause the liquid to pass through the longer glass tube, and emerge from the tapering end in a stream. If this stream be directed to the precipitate on the filter, the latter can be thoroughly and easily washed (Fig. 127).

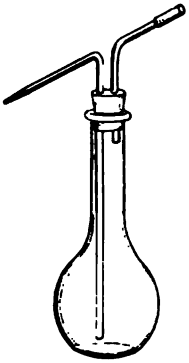


Fig. 127.—Spritz bottle.

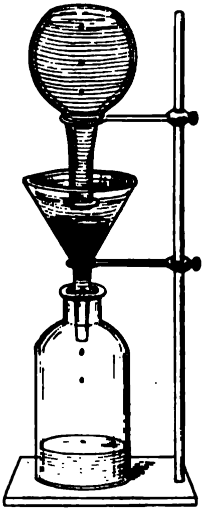


Fig. 128.—Continuous washing.

Where large quantities of a liquid are needed for washing, it is a simple matter to devise a continuous process of washing, as shown in appended cut (Fig. 128), in which it will be seen that a flask filled with water is inverted into the funnel containing the precipitate on the filter, upon which the liquid rushes until it reaches the mouth of the flask, when the flow ceases, owing to the inability of the air to pass into the flask. As the liquid of the funnel filters, its surface becomes lower than the mouth of the flask, thus permitting the entrance of air, causing a flow of the washed liquid from the flask until its mouth is again closed by the liquid in the funnel, and this continues until the flask is emptied, and that without danger of the liquid running over the edge of the funnel. Such simple apparatus is of great value in continuous filtration, in which case it is a simple matter to filter gallons of a liquid through a half-gallon funnel.

DECANTATION

In some cases it is more convenient to wash a precipitate by placing it in an appropriate glass vessel, such as a beaker or a flask, mixing thoroughly with a wash liquid, and allowing it to stand until the precipitate has completely subsided, and then removing the liquid by decantation; that is, by gently lifting the container and gradually tilting same until the major part of the liquid has been removed from the precipitate. It is manifestly impossible by this means to thoroughly remove all the liquid, as no matter how carefully decantation is continued, certain portions of the precipitate will be disturbed and flow out with the decanted liquid which, therefore, should be passed through a filter to collect the escaping precipitate. Repeated decantation, however, will enable us to thoroughly remove soluble matter from the precipitate. Thus, a precipitate contains 100 grammes soluble impurities: by treating with 1000 mils water, the 100 grammes soluble matter will dissolve. By decanting this, it is possible to remove 900 mils. of the liquid without seriously disturbing the precipitate, and in 900 mils 90 grammes of soluble impurities will be contained. To the remaining liquid and the precipitate another 1000 mils water is added, the product thoroughly mixed, and the precipitate allowed to settle. When 900 mils of this second liquid are removed, it means that of the 10 grammes soluble substance remaining, 9 grammes will have been removed, leaving with the precipitate but 1 gramme of the original 100. The operation repeated, the 900 mils of the decanted liquid will remove 0.9 of the remaining gramme of the soluble impurity, and thus, after three such washings, but one one-thousandth of the original impurity remains.

Ordinarily, however, such thorough washing by decantation is not carried on, as it means the use of too much water.

Apparatus for decantation is the container mentioned above, consisting either of a pint flask or a beaker, provided with a pour-out or lip.

To facilitate the removal of the decanted liquid, a glass guiding rod is used, such as was described on p. 91. The method of application is best shown by appended cuts (Figs. 129 and 130). To avoid the possibility of any of the liquid being drawn over to the outside of the beaker by the capillarity of the glass, the edge of the beaker should be smeared with traces of some fat. The guiding rod is of great value in quantitative analysis, in which case every particle of the precipitate must be finally removed from the beaker and weighed. This is accomplished by slipping a small piece of rubber tubing over the end of the guiding rod and rubbing the sides of the beaker with same. Such rubber-tipped guiding rod is technically called a "policeman."

Where large quantities of liquid are to be decanted, recourse is had to the **syphon,** which consists of a bent tube, one arm of which is longer than the other. The shorter arm is placed in the liquid to be removed, and at the other end of the tube suction is applied (Fig. 131).

We take a syphon, immerse the short arm in water, and suck at the orifice of the longer arm. This has the effect of producing a partial vacuum in the tube—a pressure of air therein much less than the pressure of the atmosphere exerted upon the surface of the liquid in which the short arm is plunged. The result is that the superior pressure of the atmosphere forces the water into the syphon through the short arm, around the bend, into the long arm—this result, of course, being simultaneous with the suction applied at the end of the long arm. Entering the long arm, the liquid is subjected to the earth's gravitating force and falls downward. As each drop emerges from the syphon, were nothing to take the place occupied by that drop, a partial vacuum in the syphon tube would occur. Equilibrium—an exact balance between two parts of a machine or system—is the rule of nature, hence difference in pressure in the long and short arms of the syphon is not permitted, and the instant a partial vacuum is produced in the long arm, the water in the short arm and in the vessel into which the syphon dips, impelled by an atmospheric pressure, passes over to occupy the void.

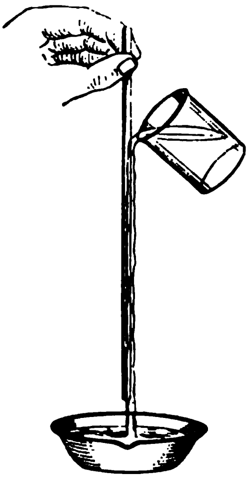


Fig. 129.—Decantation from beaker.

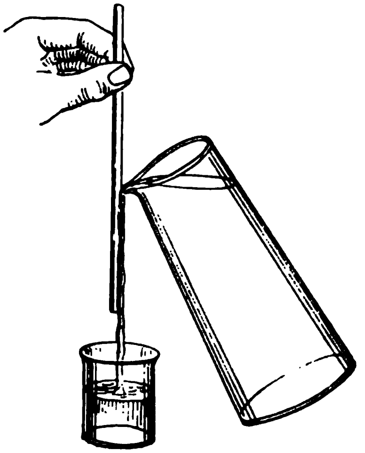


Fig. 130.—Decantation from precipitating jar.

Just as rapidly as water emerges from the long arm, even so rapidly does water pass over from the short arm to take its place, and this condition continues so long as the short arm dips in water and the level of this water is higher than the level of the water that issues from the long arm.

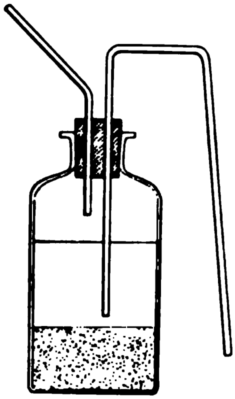


Fig. 131.—Syphoning.

COLATION

Colation is the technical name for the simple process of straining, by which term is meant the removal of coarse particles from a liquid by passing through a fabric the meshes of which are comparatively coarse. Thus, the domestic utensil, the colander, is useful in colation. In the same way a sieve can be used for the purpose of straining a liquid, but ordinarily the fabric through which the substance is passed is of some form of cloth. Among the various cloths used for straining are felt, flannel, muslin and cheese-cloth.

Felt strainers (Fig. 132) are usually of conic form and yield a liquid as clear as if filtered. Equally useful is a strainer made of flannel (Fig. 133), and these are generally sewed together in the same conic form as the felt strainer, while the muslin and cheese-cloth strainers are simply-pieces of these fabrics fastened to a frame (Fig. 134). The latter consists of four pieces of wood, joined and studded with projecting nails, on which can be fastened the straining cloth. The latter should fit tightly to the frame without edges projecting, as in the latter case each filament of the cloth acts as a syphon and part of the liquid runs over the sides of the strainer to the container in a way that scarcely betokens pharmaceutic elegance.

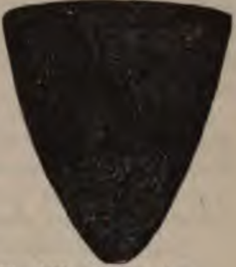


Fig. 132.—Felt strainer.

In many cases of straining the operation has been aided by what has been termed "forcible straining." which means removing the straining cloth from the frame, gathering between the hands by a twisting movement the strainer and the residue thereon, and then expressing (p. 156). Straining is an imperfect operation, inasmuch as the strained liquid is rarely as clear as the careful pharmacist desires to dispense; hence, in most pharmaceutic operations filtration is far preferable.

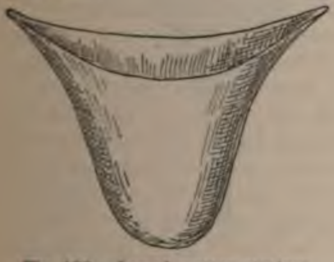


Fig. 133.—Leg-of-mutton strainer.

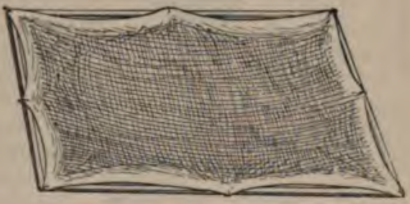


Fig. 134.—Strainer on frame.

FILTRATION

Filtration is a nearly perfect variety of straining; in both processes the operation of clearing the liquid being purely mechanical. As an illustration bringing this forcibly to mind, let us imagine we have a ditch of dirty water in which are pieces of wood (large and small), waste paper, and suspended mud. The ditch narrows to an underground drain, and, in order that the drain does not become clogged up, a grating is placed at its entrance This grating is perhaps only six or seven iron bars, but as the water passes by them, some of the wood and paper, not able to pass through the spaces, remains on the grating. Suppose we take that water which has passed through the grating into the drain-pipe and examine it. It will be found as dirty as before, save that the larger chips and the masses of paper are removed. It contains bits of straw, slivers of wood, and fragments of paper pulp that were small enough to pass through the grating. This unsightly mixture we pour on a strainer of cheese-cloth. The meshes in this are much smaller, of course, than the spaces in the grating, and the liquid emerges from the strainer much clearer, the strainer having kept back straw, wood-fiber, and paper pulp, along with considerable of the muddy sediment. However, it is still far from clear; the suspended mud in very finely divided form having passed through the meshes of the cheese-cloth, which were not quite small enough to retain the minute particles. So we take the cloudy liquid and pass it through filtering-paper, the meshes (the pores) of which are so small as hardly to be seen with the naked eye. This process usually completes the work of removing the undissolved particles, the liquid emerging from the filter perfectly clear.

Let it here be said that modern sanitary engineering has shown that filtration of water through long layers of sand removes not only visible dirt, but can, if properly carried out, remove bacteria of disease. Notable among such efforts are the water-works systems of Altona, Germany, and Lawrence, Massachusetts.

The substance which removes the impurities is called the filtering medium, and the clear liquid, the *filtrate.*

Apparatus used in filtration consist of the bottle or other container into which the filtrate drops and the container holding the filtering medium. The latter in small operations consists usually of a funnel, while in large processes of filtration it consists of earthenware crocks, or tanks of iron, wood, or masonry. The latter being beyond the province of this work, reference will be had solely to *funnels.*

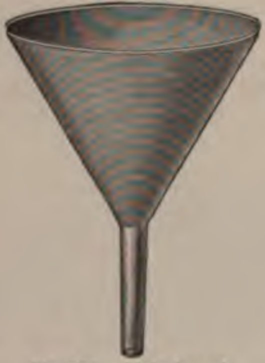


Fig. 135.—Plain funnel.

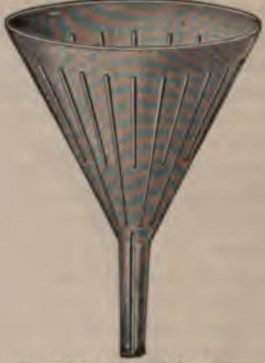


Fig. 136.—Ribbed funnel.

Funnels consist of conic vessels of glass, porcelain, or metal, although the latter should be carefully avoided in delicate pharmaceutic operations. To secure the best success from a funnel, it is necessary that the cone shall be at an equilateral triangle, as otherwise folded filter-paper will not accurately fit same. Of the many varieties of funnels suggested for pharmacists' use, reference can be had here merely to a few types. It has been the writer's experience that just as good results are obtained by using a plain glass funnel (Fig. 135) as can be secured with more elaborate varieties, the main point in successful filtration being the correct folding of the filter-paper. A very popular form of funnel is the one with the ribbed interior, to permit the passing down of the filtered liquid (Fig. 136). This, however, can be accomplished just as well by the plaits of a carefully folded filter.

The same funnel is provided with a groove on the under side of the neck of the funnel to permit the exit of air from the bottle into which the liquid is filtered. It is better pharmacy, however, not to place the funnel directly in the neck of the receiving bottle, but to support it on a ring of the retort stand (Fig. 137).

If circumstances are such that the funnel must be placed in the neck of the bottle, some provision for access of air must be made, and this is done by interposing between the neck of the funnel and that of the receiving bottle a piece of cord; otherwise the air within the bottle becomes compressed as the liquid passes into the bottle until either the liquid ceases to filter through or the air, in forcing its way out, pushes with it a certain quantity of the filtered liquid to the outside of the receiving flasks, producing an untidy operation.

This is particularly the case if the neck of the funnel is either too large or too short. It should enter completely the neck of the bottle and pass within the wider portion of same.

The **filtering medium** consists of paper, cotton, asbestos, sand, or stone, the first two being generally used in retail pharmacy.

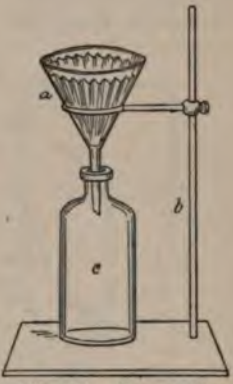


Fig. 137.—Correct filtration: *a*, Funnel; *b*, filtering stand; *c*, receiving bottle.

Paper filters consist of sheets of unsized paper, which, when properly folded, form a conic bag on which the liquid to be filtered is poured. In commerce we find two varieties of such filter-paper, one being gray and the other white. The latter is more expensive than the gray, but is preferable for pharmaceutical use.

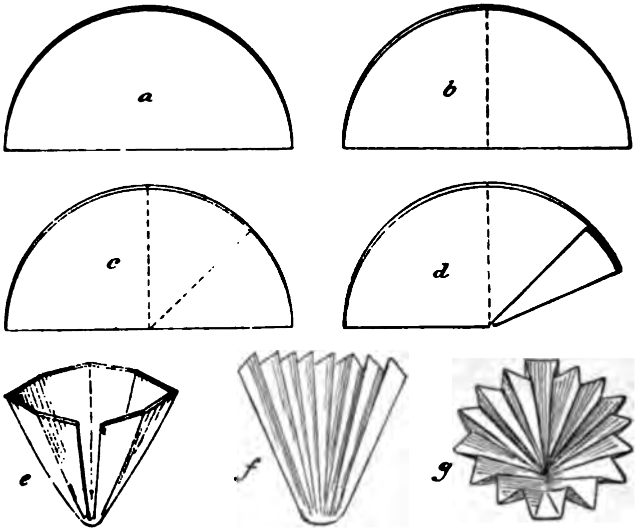
The filter-paper can be folded in two ways (usually termed *plain* and *plaited filters*), and each has its peculiar use, plain filters being indicated when the precipitate is desired, and plaited filters when the filtrate is sought for.

In making a plain filter, the paper is folded but twice, in each case the sheet being divided exactly in half. The result is a perfect cone, with one thickness of paper on one side and three thicknesses on the other, which naturally produces unequal filtration. In order to equalize, we very frequently use two such plain filters, so alternating that both sides will be four layers of the filter-paper. At its best a plain filter does not remove the liquid with rapidity because the paper lies flat against the surface of the funnel, and the only place through which the filtrate can readily pass is at the point which lies exposed at the neck of the funnel. Therefore, for rapid filtration, a plaited filter is best.

In the plaited filter the paper is so folded as to make a cone of equal thicknesses on all sides, and is also provided with canals through which the filtrate can run. The plaiting of a filter is a matter of considerable skill, and there is but one correct way to fold a successful filter. To thoroughly understand the method it is necessary to accompany the explanation by illustrations (Figs. 138 and 139). The circular piece is folded exactly in the center (*a*). This semicircle is again folded in its center (*b*). The semicircle is then opened and half of the semicircle is folded upon the central crease (*c*). This gives one-fourth of the circle divided into eighths, and these eighths are now folded into sixteenths (*d*), each fold being against the upper surface of the filter-paper.

Attention is then paid to the other fourth of the circle, it being folded exactly as was the first fourth, and as a result it being folded into sixteenths as shown in (*e*). These sixteenths are then divided into thirty-seconds by folding each back on itself, and when finished the unopened filter should present the appearance of (*f*), that is, a series of perfectly symmetric plaits, only two of which will rest against the edge of the funnel, and these can be removed by folding same into sixty-fourths, as (*g*). The observance of the following details will contribute to attaining the ideal in filtration:

First, the folds of the filter should not be permitted to extend to the point of the filter, but in plaiting the filter the crease should be made from the point toward the edge, a finger being kept on the point to prevent the creasing of same. The necessity of sparing the point can be understood when it is appreciated that every crease in the piece of paper contributes to the weakening of same, and, therefore, the passing of sixteen creases across the central point forming the tip of the filter is apt to so weaken it that it will break as soon as the liquid is poured upon it, the greatest pressure of the liquid being exerted on the filter tip.



Figs. 138 and 139.—Folding plaited filter (see text).

Second, the filter should be moistened before filtering. This opens the pores of the filter, rendering easier the passage of the liquid through the filter. It is needless to say that the filter should be moistened with the liquid which is the solvent for the drug intended to be filtered. Thus, to moisten with water a filter through which it is intended to pass essence of ginger, would be doing much more harm than good. The moistening of such a filter should be done with alcohol.

Third, when the filter is moistened, it is advisable to push the tip of the filter fairly well down into the neck of the funnel. This serves to strengthen the filter tip.

Fourth, in pouring the liquid on the filter, avoid throwing it directly on the tip, but gradually pour it upon one side of the filter, as otherwise the force of the fall is apt to rupture the paper.

Fifth, the paper should not project above the funnel. It is a human failing to fill the filter as completely as possible, and in case the paper projects over the side of the funnel, the actual level of the liquid may be above the top of the funnel, and a rupture of the paper brings disastrous results. The chief reason, however, for this rule is that the projecting paper affords considerable surface exposed to the air, thereby producing spontaneous evaporation, with accompanying loss of the liquid. This is particularly the case when the liquid to be filtered is volatile.

Cotton Filter.—In many cases of simple filtration all that is necessary to remove the insoluble matter is the passing of the liquid through a pledget of cotton placed in the neck of the funnel. This method of filtration is one which should be practised more frequently behind the prescription counter than is usually the case. Every prescription calling for a solution should be dispensed absolutely clear, and to insure this the finished solution should be filtered through cotton before dispensing. If three or four funnels of various sizes be kept within reach and a package of absorbent cotton be kept in the drawer of a prescription case, such filtration is exceedingly simple, the custom of the writer being to filter directly into the bottle in which the prescription is dispensed.

Asbestos Filter.—Instead of a plug of cotton, a similar plug of purified wooly asbestos inserted in the neck of the funnel affords an admirable method for the filtering of strong acid or alkaline liquids, which would destroy filter-paper or cotton. Such asbestos wool can now be easily obtained at moderate cost, and should share a place in the drawer in which the absorbent cotton is kept. By means of the asbestos it is a very simple matter to filter a solution of soda or solution of potassa.

Sand- and **stone-filters** are used in large operations only, such as filtering drinking-water. The sand-filter usually consists of a vat in which are placed alternate layers of sand, charcoal, and gravel, usually to a depth of two or three feet. Upon this the water is thrown and percolates through to the bottom, and is drawn off by means of a faucet.

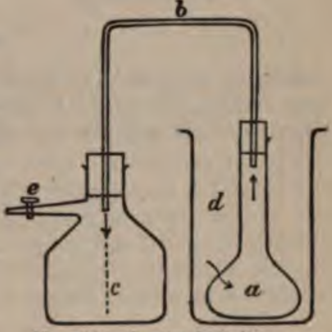


Fig. 140.—Porous flask filter.

Many patent varieties of stone-filters are in the market, they consisting of porous stones cut into shapes suitable for the container, and through which the liquid passes. A very convenient and small modification of the stone-filter is the porous flask (Fig. 140), which is attached to a syphon and placed in a vessel containing the liquid desired to be filtered. The play of the syphon once established, the liquid passes from the original container through the porous flask, and emerges from the syphon completely filtered.

Filtration through Absorbent Powder.—This is a modification of filtration where the separation of the insoluble matter is facilitated by the use of some powder that has the property of adsorbing such material. On a small scale the powders employed are magnesium carbonate, talc, infusorial earth, etc., these being used to aid filtration through paper. In this way some of the official aromatic waters are prepared (p. 174).

Adsorption is now recognized as an important phenomenon in physical chemistry; the holding back of the matter by the absorbent powder being akin to atomic attraction (p. 346).

Volatile Filtration.—In case the liquid to be filtered is volatile, precautions must be taken to prevent undue evaporation. This is usually accomplished by placing the filter-paper in a funnel considerably larger than itself, covering the funnel with a sheet of rubber or plate of glass, while the neck of the funnel fits into a cork stopping the neck of the receiving bottle. In order to permit exit of air from the receiving bottle and ingress of air into the top of the funnel, these two may be connected with a rubber or glass tube in the same way as explained under Volatile Percolation (p. 166).

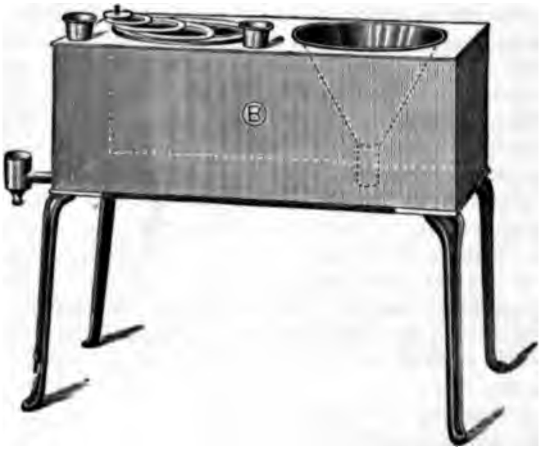


Fig. 141.—Hot filtration bath.

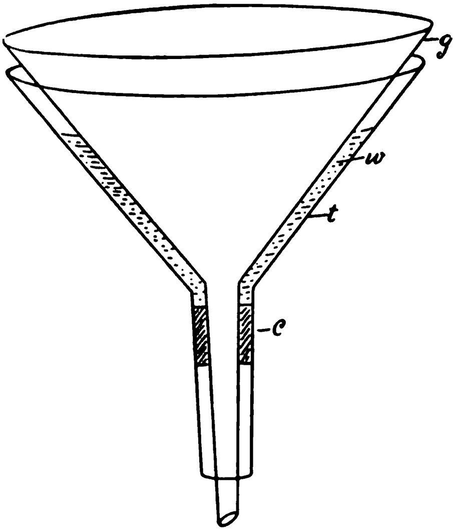


Fig. 142.—Funnel for hot filtration: *g*, Glass funnel; *t*, tin funnel; *w*, water; *c*, cork (Hatcher and Sollmann).

Hot Filtration.—Some liquids can be filtered only when quite hot, and with certain easily fusible solids the best method of purification is by filtering same in the molten state; such, for example, is the case with wax. In all such cases the funnel containing the filtering liquid must be kept warm, and for such purposes various forms of hot filtration apparatus have been devised (Fig. 141). These usually consist of water-baths with the conic holes in which the funnel will fit. A cheap and practical form of such hot filtration apparatus, devised by Dr. R. A. Hatcher, consists of a tinned iron funnel with its neck closed by a perforated cork, through which passes the neck of a glass funnel. In the space between the inner wall of the metallic funnel and the outer wall of the glass funnel water is placed and kept warm by means of a Bunsen burner (Fig. 142).

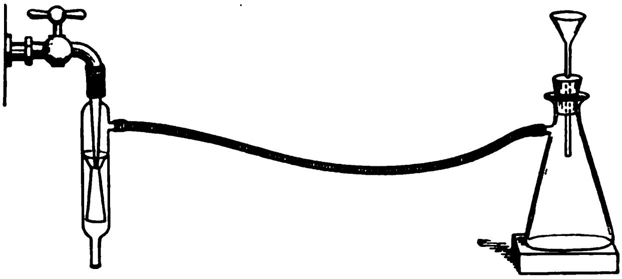


Fig. 143.—Rapid filtration.

Rapid Filtration.—In many cases of ordinary processes of filtration the liquid filters through so slowly that some means to increase the flow is necessary. This is usually accomplished by fitting the receiving bottle with a two-holed rubber cork, through one perforation of which the neck of the funnel passes, while the other is fitted with a bent glass tube connected with an apparatus which will rarefy the air within the receiving bottle (Fig. 143). A special form of receiving bottle is obtainable in which the air is drawn off by a tube connected from the side of the bottle (Fig. 144). In such cases the pressure of the atmosphere acting on the surface of the liquid in the filter is greater than the pressure within the receiving bottle, and hence forces the liquid through the pores of the filter into the receiving bottle, and that frequently with such great force as to rupture the filter-paper unless some means is taken for its protection. This is usually accomplished in filtering liquids in quantitative chemistry by fortifying the tip of the filter-paper with a cone of perforated platinum. Such quantitative precipitates, however, can best be separated from the liquids in rapid filtration by use of the Gooch crucible filter (Fig. 145), which consists of a porcelain crucible provided with a perforated bottom in which is inserted a plug of asbestos, and this,

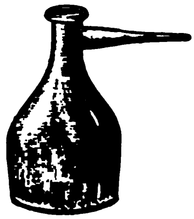


Fig. 144.—Filtering flask.

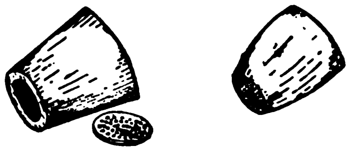


Fig. 145.—Gooch crucibles.

by means of the large rubber tubing, fitted to the smaller funnel connected with filtering flask (Fig. 146).

The rarefication of the air within the flask can be accomplished with the water-pump pictured on p. 92, or, in its absence, sufficient air can be removed by the simple expedient of syphon suction.

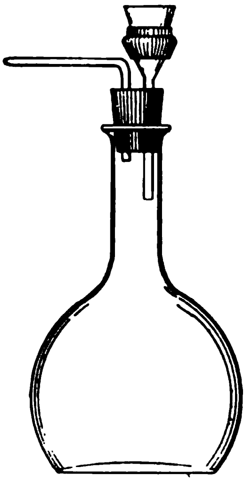


Fig. 146.—Gooch crucible in filtering flask.

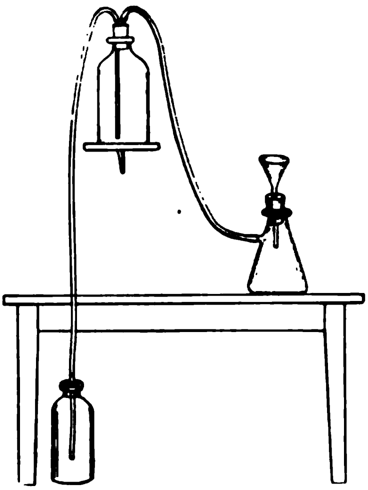


Fig. 147.—Syphon filtration.

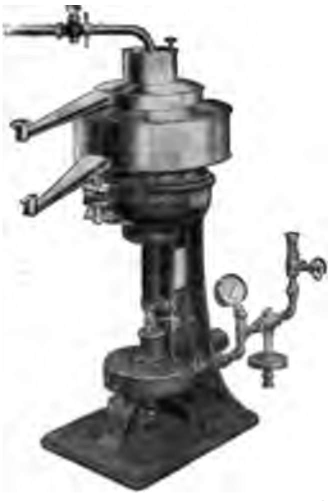


Fig. 148.—The De Laval clarifier and filter.

The apparatus consists of two one-gallon jugs, each fitted with two-holed corks. Through the orifices of each cork passes bent glass tubing, one extending to the bottom of the jug, the other only a few inches below the under side of the cork. In the operation one jug is filled with water, placed on a table, and connected with the other jug placed on the floor by rubber tubing attached to the long glass tube of each jug. The small glass tube of the upper jug is fitted by thick rubber tubing to the end of the aspirator, and the water in the jug is made to syphon over into the lower jug, thus producing a suction of the upper jug and the filtering bottle. When all water has run into the lower jug, the position of vessels is reversed and the operation continued (Fig. 147).

For the rapid filtration of large quantities of viscid fluids power filters built on the principle of cream separators are now obtainable (Fig. 148).

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CHAPTER VIII

CLARIFICATION, DECOLORIZATION, AND SEPARATION OF IMMISCIBLE LIQUIDS

CLARIFICATION

Clarification is the process of clearing a liquid without the aid of filtration. As filtration is a simple and thorough operation, clarification is substituted for it only in cases where filtration is difficult, if not impossible, as in the case of mucilaginous and other viscid liquids which will not pass through the pores of a filter. The clarification of liquids, whenever possible, is accomplished by means which are purely mechanical clarification by means of chemicals not being recommended because of danger of alteration of the liquid during the process. The apparatus for clarification is usually of the simplest character, consisting generally of a vat, kettle, or dish, and some form of strainer through which the liquids are passed to remove it from the solids. Clarification is accomplished in the following ways:

1. *Heating.*—In many cases the liquid to be clarified is turbid by reason of suspended or partially dissolved albumin or wax. In such cases heating usually accomplishes clarification by coagulating the albumin or by causing the waxy substance to liquefy and rise to the surface. After such cases of clarification the cool liquid is either strained, or the separated solids float on the surface (scum) and are removed by skimming. An illustration of this kind of clarification is the process of clarifying honey, as given in the pharmacopœia of 1880.

2. *Increasing Fluidity.*—In some cases suspended particles of dirt, grit, and straw make turbid a liquid which is so viscid that these particles can neither rise to the surface of the liquid if lighter than same, nor sink to the bottom if heavier. This can be remedied by diluting the liquid with water until sufficiently limpid to permit separation of the solid matter and then evaporating the excess of water.

3. *By Use of Albumin.*—The method given above is not always satisfactory, as frequently it is inconvenient to evaporate the excess of water, and, moreover, it is often the case that the particles do not separate of their own volition. The separation of these particles can be facilitated by thoroughly mixing white of egg with the liquid and then heating the mixture, when the albumin coagulates and rises to the surface of the

liquid, carrying with it the mechanical impurities, which are skimmed off along with the solidified albumin. By this process boiled coffee is rendered clear.

4. *By Use of Milk.*—In the above operation milk is sometimes substituted for albumin, this acting the same way by reason of the coagulation of the casein it contains.

5. *Paper Pulp.*—A similar mechanical separation of the particles can be accomplished by tearing filter-paper into shreds, mixing it thoroughly with the liquid, and heating. When the paper rises to the surface it carries with it the suspended particles, which are removed by skimming. The official method of clarifying honey combines the use of paper pulp with increasing the fluidity of the liquid.

6. *By Sedimentation.*—If the particles rendering the liquid turbid are sufficiently heavy, they will settle to the bottom of the containing vessel, even though the liquid is quite viscid, if sufficient time is given to accomplish the separation. This slow method of separation is called *sedimentation*, and the insoluble matter finally settling at the bottom of the vessel is called the *sediment*. The term *precipitate*, frequently applied to the sediment, is incorrect, as by precipitate we mean insoluble matter which has been in solution, whereas the particles composing sediment have never been dissolved.

7. *By Use of Gelatin.*—Gelatin is only employed for clarifying liquids containing tannin, the action in this case being chemical, and not mechanical. Gelatin forms with tannin an insoluble combination, similar to leather.

8. *By Fermentation.*—This is a method of clarification, the application of which is limited to the preparation of fruit-juices used at soda fountains. The preparation of these is a very simple matter. Fruit is crushed either by pounding in a tub or by means of a fruit-crusher or grater, and the pulp allowed to stand in a comparatively warm place for twenty-four hours. Partial fermentation is begun, and the slight change in the chemical character effects a separation of the clear juice from the pulp and albuminous matter, permitting the easy separation of the juice from the insoluble matter by straining, and the strained juice is then placed in bottles, corked, and sterilized by submitting to the action of boiling water for half an hour or more, or, if preferred, the sterilization can be omitted and the fruit preserved by the addition of alcohol. Some of the commercial juices are preserved by the addition of salicylic acid or other preserving agents, but in most States the addition of these preserving agents is prohibited by legislative action.

DECOLORIZATION

Decolorization is the process of removing color from a substance, and is usually accomplished by macerating the solution with animal charcoal for several days and then filtering. Animal charcoal is the only convenient substance possessing this decolorizing property, due to the powers of absorption it possesses. This absorbing ability is not limited to coloring-matter, but also to glucosides, alkaloids, and bitter principles, hence in decolorizing decoctions of the drugs containing the latter substances by animal charcoal they suffer some loss in active principles. (See p. 386.)

SEPARATION OF IMMISCIBLE LIQUIDS

By immiscible liquids we mean two liquids which do not dissolve in each other, for example, water and oil, and in cases where these two are brought together, it is very frequently useful to have a means of separating them readily. In some cases immiscibility is intentional. For example, in alkaloidal assays, we pour into an alkaline aqueous solution some "immiscible" solvent such as ether or chloroform in order that the alkaloid can be taken out of the aqueous layer by the added solvent. (See Part V.) Immiscible liquids are separated by several methods. In case the amount of one of the liquids is very small, it can be separated from the other by means of a *pipette*, one end being placed in the liquid, which is drawn into the pipette by means of suction (Fig. 149).

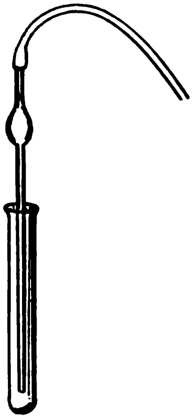

Fig. 149.—Separation of immiscible liquids with pipette.

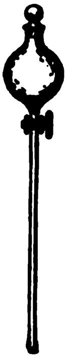

Fig. 150.—Separatory funnel.

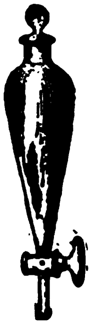

Fig. 151.—Squibb's separatory funnel.

A similar form of crude separation can be accomplished more thoroughly by a cheap glass *syringe*, the suction in this case being accomplished by moving the piston. Both these means of separation, however, are very primitive, and should be used only in emergencies. Absolutely thorough separation can be accomplished by the inexpensive *separatory funnel* (Figs. 150 and 151), which consists of a glass tube provided with a glass stopper and terminating in a tapering tube to which is fitted a glass stop-cock. For those economically inclined, an ordinary glass funnel can be used as a separatory funnel by fitting in the neck of same a velvet cork, fitted with a glass rod, and allowing the liquid to run out from the funnel by raising the cork and pressing it down when the last portion of the heavy liquid has been separated. Considering, however, the low price of a separatory funnel, the use of this crude apparatus is hardly justified.

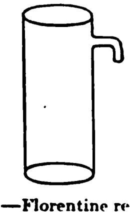

Fig. 152.—Florentine receiver for heavy liquids.

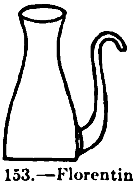

Fig. 153.—Florentine receiver for light liquids.

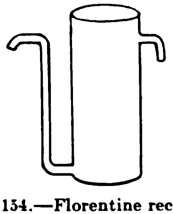

Fig. 154.—Florentine receiver combined.

One immiscible liquid can be crudely separated from another by means of a *syphon*, but to this method the same comments can be applied as to separating with a syringe.

By Florentine Receiver.—For the separation of a quantity of immiscible liquids too large for the separatory funnel, recourse is had to the Florentine receiver (Figs. 152, 153, and 154), this being used in the steam distillation of substances containing volatile oils to separate the volatile oil from the water which accompanies it in the distillation. As shown in cuts, two forms of such receiver are used, accordingly as the oil is heavier or lighter than water, each apparatus being so arranged as to cause the flowing out of the water and retention of the oil in the receiver, while the third cut shows a receiver adapted to either light or heavy oils.

A crude method of separating chloroform from large quantities of water, such as is sometimes required in the extraction of alkaloids from drug decoctions by shaking with chloroform, is by agitating the mixture in a five-gallon demijohn or can, and suddenly inverting same into a quart or half-gallon wide-mouthed bottle, and when the chloroform has completely separated into the jar, the demijohn is removed and the chloroform separated from last small quantities of water by use of an ordinary separatory funnel.

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CHAPTER IX

PRECIPITATION, CRYSTALLIZATION, GRANULATION, EXSICCATION, AND DIALYSIS

PRECIPITATION

Precipitation is the process of separating a solid from its solution by the aid of physical or chemical action. The substance so separated is called a *precipitate;* the chemical producing this precipitate is called the *precipitant,* while the liquid remaining above the precipitate substance is termed the *supernatant liquid.*

As mentioned in the last chapter, a precipitate differs from a sediment in that a precipitate is separated out from its former state of solution, while a sediment has never been dissolved. In order to precipitate a substance it is necessary to first get it into solution. On the other hand, the precipitated substance is, in the nature of things, a substance insoluble in water, and must, therefore, be dissolved by special agents, the act of solution frequently bringing about a chemical change.

Precipitation may be due to chemical or physical causes. The most important phase of precipitation is that involving chemical action, wherein the two reacting substances are dissolved in separate portions of water, and on mixing these solutions an insoluble body will be formed and precipitated.

But we have precipitations that are due to purely physical causes. Thus from a hot supersaturated solution on cooling will be precipitated the excess of dissolved substance. Likewise, solution of such substances which are more soluble in cold water than in hot (like lime) will be precipitated when they are heated, such cases being examples of precipitation through change in temperature. We have learned that substances may be soluble in one liquid and insoluble in another; thus, gum arabic dissolves in water, but is insoluble in alcohol. If alcohol is added to a solution of acacia, it diffuses through the water and the acacia is precipitated, an example of precipitation through change in menstruum.

Objects of Precipitation.—We precipitate substances chiefly to *purify* same. As will be noted later, the purification of chemicals which are soluble is easily effected by crystallization, and likewise, the purification of insoluble chemicals is generally accomplished by precipitation, and in both cases the act of purification is accomplished by bringing the substance into solution. Therefore, in precipitation we dissolve a substance in some way usually by changing the identity of the chemical. The solution thus obtained is rendered free from insoluble extraneous matter by filtration, and to the filtered liquid is added the appropriate precipitant, which converts the chemical into the insoluble form desired, leaving the soluble impurities in the supernatant liquid.

Another object of precipitation is to *obtain the substance in fine powder*, the insoluble matter usually separating out in almost molecular subdivision.

A third object of precipitation is for *its value in chemical testing*. Practically the entire scheme of analytic chemistry (Chapter LII.) is based on the separation of the various elements from solution by the addition of an appropriate precipitant.

Operation.—As mentioned above, precipitation can be accomplished by either physical or chemical means, although by far the greater number of precipitates used in pharmacy and chemistry are produced by chemical means. Among the physical means of precipitation is the use of *heat*, as shown by the precipitation of the egg-albumen from the mixture by heating when the albumen coagulates, as explained in the preceding chapter.

Another physical form of precipitation is *by changing the nature of the solvent*. As mentioned in Chapter VII., a substance may freely dissolve in one solvent, but be insoluble in another, and in such cases the addition to the solution of the substance of the liquid in which it is insoluble usually effects the precipitation of the solid, provided always that the added liquid is freely miscible with the liquid which holds the salt in solution. A case of this kind is that of acacia, which will be precipitated from its aqueous solution on the addition of alcohol. This separation, it will be noted, is purely physical, and it differs from the precipitation of acacia from its aqueous solution by the addition of lead subacetate, in which case chemical change is effected.

Among the chemical means of precipitation it is possible to include the action of *light*. Even that precipitation is frequently considered as a physical means, but it is true that precipitation effected by light is brought about by the light changing the chemical character of the precipitated substance. One case where light produces precipitation is with the salts of silver. Almost every pharmacist has noted the precipitation occurring in solution of silver nitrate exposed to the light when the sides of the vessel become coated with a black substance, which is metallic silver, the light acting on silver nitrate, reducing it to the metallic form. The usual chemical method of precipitation, however, is *by adding a precipitant*, as mentioned above, and as illustrated in the manufacture of precipitated calcium carbonate from prepared chalk.

These two substances are chemically identical, the only difference being that prepared chalk—a natural product—is only slightly purified by the process of elutriation and trochiscation; hence is apt to contain more or less impurities, and it is freed from these impurities by the process of precipitation.

In converting the prepared chalk into calcium carbonate, five stages in the operation may be noted. The first is to get prepared chalk or the calcium part of it into solution, for it is through solution that a substance can be readily freed from impurities.

To effect this solution a chemical change is necessary; in other words, the insoluble calcium carbonate must be converted into a soluble salt of calcium, and the salt selected is calcium chloride. This calcium chloride is produced from the prepared chalk by the addition of hydrochloric acid, the reaction being:

$$CaCO_3 + 2HCl = CO_2 + H_2O + CaCl_2.$$

The calcium chloride solution so obtained is filtered to effect a separation of insoluble particles, and this filtration might be considered the second stage of the process. The third stage of the process is the real precipitation, which is accomplished by adding to the solution of calcium chloride the precipitant, which is a solution of any soluble carbonate, and for practical purposes sodium carbonate is always used, the reaction at this stage being:

$$CaCl_2 + Na_2CO_3 = 2NaCl + CaCO_3.$$

It will be seen that, besides calcium carbonate (precipitated chalk), sodium chloride is formed, and the moist precipitated carbonate is wet—not with pure water, but with a solution of salt. If we dry the precipitate just as it separates from the liquid of which it was once a part, we get a product contaminated with salt, but if we wash it, the sodium chloride dissolves, leaving behind pure calcium carbonate moistened only with water.

Therefore, we wash the moist precipitate, this constituting the fourth stage in the process of precipitation. Lastly, the moist precipitate must be dried, which constitutes the fifth and last stage of the process.

Apparatus used in precipitation by chemical means consist of a chemical flask or evaporating dish in which the insoluble substance is made into the soluble form, the funnel and filter by means of which the solution is rendered clear, the jar or dish in which the filtered solution is mixed with the precipitant, and where the precipitate is allowed to collect, a strainer or a plain filter in which the precipitate is collected and washed, and, lastly, a drying closet or other means of desiccation by which the moist precipitate is dried. All these pieces of apparatus have been considered except the precipitation jars; these consist either of tall cylinders or of beakers, both of which were illustrated under Decantation (Figs. 129, 130). The precipitating jar is of glass, made tall in order to effect the complete separation of the precipitate, thus facilitating decantation; the beaker is a vessel of thin glass so annealed as to stand heating.

For precipitation in chemical testing, test-tubes are usually employed. These consist of narrow cylinders of glass, five or six inches long, with round bottoms (Fig. 155), while in quantitative analysis the precipitates are carefully collected in a beaker, as explained under Decantation.

The appearance of the freshly separated precipitate is described by appropriate adjectives, most of which are self-explanatory. Thus, we say that silver chloride is *curdy;* ammonio-magnesium phosphate is *crystalline;* aluminum hydroxide is *gelatinous;* coagulated albumin is *flocculent*, and magnesium phosphate is *granular*.

Sometimes, when a precipitate is light and occupies considerable space, it is said to be *bulky*. A *magma* is a form of thick, tenacious precipitate, such as is formed by magnesium hydroxide in the official magma of magnesia.

In explaining a test, mere mention of the precipitant is not sufficient, but the color and character of the precipitate formed should be included in the answer. Thus, if asked the test for sulphuric acid or a sulphate, it is scarcely complete to answer "barium chloride," but such a question should be answered: "Barium chloride gives a white precipitate, insoluble in nitric and hydrochloric acid." The last part of this answer, while seemingly superfluous at first glance, is necessary, inasmuch as barium chloride forms white precipitates with several other acids, but it is only in the case of sulphuric acid and sulphates that the precipitate is insoluble, as mentioned.

In some cases the same substance can be precipitated in a light, flocculent form or in a heavy, granular form, giving rise to the distinction between *light* and *heavy precipitates*. These result entirely from the method of manipulation. If, in precipitating the substance, the solutions are dilute and cold, a light precipitate is usually formed, whereas if the two substances are mixed in hot concentrated solution, a heavy precipitate is formed. An official illustration of these two forms of the same substance is shown in magnesium oxide, U.S.P., and heavy magnesium oxide, these being produced by the calcination of light magnesium carbonate and of heavy magnesium carbonate respectively, the light being precipitated from dilute solutions and the heavy from concentrated solutions.

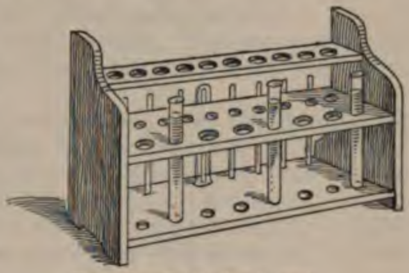

Fig. 155.—Test-tubes in rack.

CRYSTALLIZATION

Crystallization is the process of separating substances in forms possessing definite geometric angles. Such substances are called "*crystalline*" while substances which cannot be made to form definite geometric angles are said to be "*amorphous*." Among the latter are some substances which are sometimes erroneously considered crystalline, as, for example, the scale salts of iron.

In considering crystallization the first aim is to get an idea of what a crystal is. A crystal is a solid whose forces form definite angles, a body which can be measured according to the rules of geometry. Geometry is that portion of mathematics which deals with the measurement of surfaces and angles. Angles are formed where surfaces meet and vary in size, being measured by their relation to the circle. Thus, were a right angle cut from a circular disk from center to edge, it would remove one-quarter of the circle. A circle in geometry is divided into 360 parts, called degrees, and since the right angle is one-quarter the circle, its measurement is said to be 90 degrees. An angle of 60 degrees is but one-sixth the circle, hence is sharper than a right angle.

An angle means what we usually call a corner—a space inclosed by the intersection of two straight lines. We have instruments whereby these angles may be measured, and the measurement of the various angles forms a part of the sciences of geometry and trigonometry. Among the practical applications of these sciences may be mentioned surveying and measurement of crystals. In physics and astronomy a knowledge of these sciences is essential.

Crystals are specially interesting as definite geometric forms assumed of themselves without outside aid. It is an easy matter for a skilled sculptor to hew a definite geometric form, but remember that a crystal form depends on no human aid. The substance composing the crystal groups its particles into the shape ordained for it from the beginning, and every perfect crystal of the same substance, be it large or small, has exactly the same form. Then, too, all substances do not crystallize with the same angles. One for ages has been crystallizing in a certain form, while one of its neighbors during the same period has produced numberless crystals all alike, but each of shape different from the substance first spoken of. In this way we have in the study of crystals an excellent method of distinguishing different chemical substances, and so large is the scope of the work that study of crystals is now classed as an independent science.

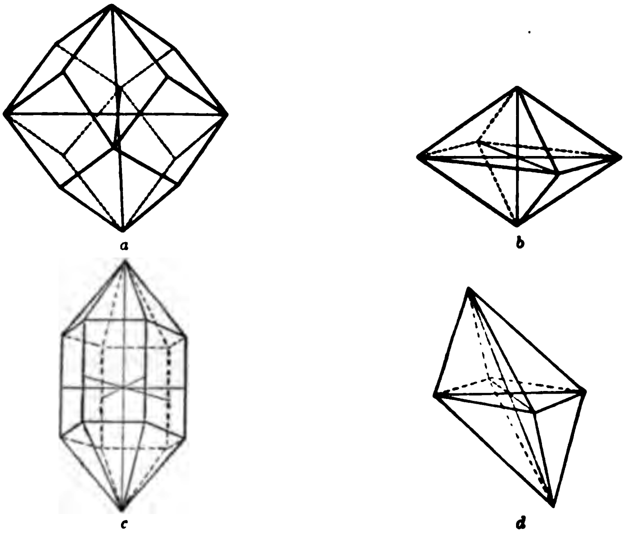

Fig. 156.—Crystal forms: *a*, Dodecahedron; *b*, quadratic octahedron; *c*, hexagonal prism; *d*, double oblique octahedron (Holland).

In studying the crystal the crystallographer distinguishes four different parts to a crystal, the most important of which are the ***angles*** described above, an angle being the measurement of the conjunction of two *faces*, such conjunction being called the *edge*. These terms will best be understood by a study of Fig. 156, which also shows the fourth characteristic of the crystal, the *axes*, these being imaginary lines so drawn through the crystal that they intersect at its center. Each crystal has its peculiarities of faces, axes, and angles, and, therefore, all substances in crystalline form are grouped by crystallographers into various crystal systems, the main divisions being as follows:

	NUMBER OF AXES	LENGTH OF AXES	ANGLE OF INTERSECTION
Regular	3	All equal.	All right angles.
Tetragonal	3	Two equal, 1 different.	All right angles.
Rhombic	3	All unequal.	All right angles.
Hexagonal	4	Three equal, 1 different.	Three at angle of 60 degrees, the fourth at right angle.
Monoclinic	3	All unequal.	Two oblique, the third at right angle.
Triclinic	3	All unequal.	All oblique.

The subject of crystallography is beyond the scope of the average pharmacist, its chief value being as an adjunct to the science of mineralogy, therefore, the rest of this chapter will be devoted to the pharmaceutic consideration of crystallization, and those desiring further information on the science of crystallography are referred to standard books on the subject. This is following the lead of the pharmacopœia, which rarely mentions the scientific classification of crystals, contenting itself with the rather superficial general terms applied to crystals, such as saying that the crystal is "prismatic" (in shape of a prism), "tubular" (somewhat round like a cylinder), "acicular" (needle-shaped), etc.

In some cases mineralogists find half-crystals; in other words, the ideal crystal is split down its length. Such crystal splitting is called *cleavage*.

Isomorphism.—Substances which crystallize into the same form are said to be *isomorphous;* and, through the investigation of Mitscherlich, has been evolved the interesting and valuable theory that isomorphous bodies usually possess closely allied chemical composition. Thus magnesium sulphate, $MgSO_4 + 7H_2O$ and zinc sulphate $ZnSO_4 + 7H_2O$ are found to be isomorphous. In the same way the alums all crystallize in the same form.

Measurement of Crystals.—As mentioned above, crystallography is the study and classification of crystals chiefly according to the angle intersection, the measurement being made by the instrument called *goniometer*. A full description of this instrument would be too technical for the limits of this work, but its principle of action can be explained by saying that in this instrument the crystal, the angles of which are desired to be measured, is placed in an appropriate holder, operating on a universal joint, capable of rotating in every direction, and the angle of rotation can be carefully measured on an appropriate scale. A telescope is part of the instrument, and through this we gaze on an image reflected from one side of the crystal, and we then gently rotate the crystal, when the image becomes lost, until the rotation has brought the adjoining face of the crystal into exactly the same position formerly occupied by the other face, when the image is forthwith restored. At this point a reading is made of the rotation of the crystal, and from this datum the angle can be determined.

Objects of Crystallization.—The pharmacist's consideration of crystallization is limited almost entirely to the production of crystals, and, therefore, the view of the pharmacist as to crystals is quite different from that of the crystallographer, the latter busying himself with the examination of the finished and usually native crystal, while the aim of the druggist is the production of a handsome crystal without special reference to the exactness of the angles. He produces a substance in crystalline form, but merely to obtain them in a higher degree of purity, and to this he adds the esthetic consideration that a perfect crystal is the most beautiful form in which a chemical can be produced.

For practical reasons, however, the pharmacist usually prefers his chemicals in the form of granular crystals, rather than a large and perfect sample, the former being readily more soluble.

Production of Crystals.—The several ways in which crystals are produced are given place in order to their relative importance:

First, by cooling a hot saturated solution. This is the usual method of producing crystals in chemical manufacture, and the process can be readily understood by one who has studied the preceding chapter on Solution. Therein it was noted that a substance is usually more soluble in hot water than in cold; furthermore, that from this hot solution, on standing, will be deposited the excess of the substance.

Thus, as cited on p. 122, 100 mils of boiling water will dissolve six times as much potassium chlorate as will 100 mils of water at 25°C., and when the temperature of this heated solution is reduced to 25°C., the 80 per cent. excess will separate out, and, indeed, in the form of crystals, since the body is crystallizable. Such is the usual method of making crystals, the substance being dissolved in hot water, the hot saturated solution filtered through paper, the filtrate allowed to stand in an appropriate dish, usually for twenty-four hours, when the liquid is separated from the crystals, which are then removed from the dish and dried.

Two technical terms are used in connection with this process. The saturated solution above the crystals in which the substance has formerly been dissolved is called the *mother liquor*, and again, in some cases of crystallizing this way a solution is concentrated by evaporating until a thin scum of crystals forms across the surface of the liquid, and this layer is called the *pellicle*.

Apparatus.—The apparatus used in this operation are the indispensable funnel and filter and the dish in which the crystals are collected. For small operations no better dish can be found than the ordinary pint evaporating dish. Glass beakers are sometimes used, but should be employed only for the collection of minute quantities, and when the crystals are not particularly large and strong as in the latter case the removal of the crystals from the sides of the vessel is liable to result in fracture of the glass. In all operations of crystallization crystals will separate out more readily if the interior of the dish is rough, although this detail is valued chiefly in crystallizing large quantities, for which purpose nothing is better than the ordinary earthenware crocks. The roughness of the vessel seems to attract the formation of crystals, the same way as does the introduction into the liquid of bits of glass or tightly stretched twine.

These extraneous aids to crystallization are called *nuclei*, and a familiar illustration of nuclei is the use of string on which rock-candy crystallizes. The finished crystal must be drained from its mother liquor, and this is usually accomplished by throwing the wet crystal mass on a strainer, or, in the case of smaller quantities, on a filter, and allowing it to drain. The excess of the liquid is then removed by placing the crystals between sheets of filter-paper, or, in the event of the substance being of a caustic nature. such as chromic acid, porous plates of unglazed earthenware are used.

Second, by the gradual evaporation of a solution. This consists of a modification of the foregoing, the crystallizing solvent being in this case alcohol, ether, chloroform, or some other volatile liquid. In such cases the chemical (usually of plant origin) is dissolved in the smallest possible quantity of the liquid, the solution filtered into an evaporating dish and allowed to stand, when, due to the gradual vaporization of the solvent, the crystals slowly form in the bottom of the dish. In such case the crystals should be removed before the solvent has completely dissipated, in order that the impurities may be removed in the solvent.

Third, sublimation. Some chemicals on subliming, solidify in the form of crystals. Such is particularly the case with benzoic acid, and this gives the method employed in the manufacture of this chemical from its natural source, the official benzoin. The drug is coarsely powdered, mixed with sand, and placed in a dish which is covered with a piece of cheese-cloth. Over the dish is placed a cone of paper, and the entire apparatus is placed on a sand-bath and heated at a temperature not exceeding 110°C. From the benzoin the benzoic acid is liberated in vapor form and rises within the cone, and is condensed by the lower temperature of the surrounding air in the form of beautiful crystals. (See p. 108.)

Fourth, by fusion and partial cooling. This method of crystallizing is of little value to pharmacists, its only application being in the preparation of one form of sulphur crystals. In this operation a considerable quantity of the substance, say 200 grammes, is placed in a Hessian crucible and brought to a state of fusion. As the pellicle forms on the surface of the cooling mass a hole is punched through, and the remaining liquid carefully poured out. On completely removing the pellicle it will be found that the sulphur has deposited in the form of monoclinic crystals. In a similar manner Moissan prepared diamonds by melting iron and dissolving graphite, therein, and allowing the mass to solidify, under great pressure, by plunging the white-hot mass into cold water. The solid mass is then treated with hydrochloric acid, which dissolves out the iron, when it is found that part of the graphite is converted into the crystalline form, diamonds, although the crystals are too small to possess commercial value. Perhaps Moissan's method is more properly considered as a case of deposition from saturated solution, as in truth the graphite is dissolved in the molten iron and is caused to separate out in crystalline form before the solvent has solidified.

Fifth, by effecting change in the character of the solvent. As mentioned under Solution, some substances are soluble in one solvent and insoluble in another. For example, sugar will dissolve freely in water and sparingly in alcohol. In this case, if to the concentrated solution of sugar is added alcohol in sufficient quantity, the sugar will separate out and, indeed, in the form of crystals. This method is used in effecting crystallization in many chemical operations, although its use in pharmacy is comparatively limited.

Sixth, by the electric current. This method is totally foreign to crystallization in pharmacy, and can be dismissed with the statement that handsome crystals of gold metal have been obtained by passing low currents of electricity through solutions of metal for long periods of time.

Water of Crystallization.—In the case of crystallization produced by a separation from a solution, the solvent very frequently plays a rôle in the composition of the deposited crystal, although in some cases the crystal separates from the solution without combining with any of the solvent. The latter is usually the case when some solvent other than water is employed, but sometimes, in separating from aqueous solution, some chemicals form crystals that are water-free. If water combines with the separating crystal, as is usually the case in aqueous crystallization, it is designated as "*water of crystallization*," and if alcohol combines with the chemical in the same way, it is called "*alcohol of crystallization*," and in similar manner we find some crystals contain "ether" or "chloroform" or "acetic ether of crystallization," if these solvents have been employed in the process of making crystals. The last four cases are not usual, however, so our attention need be devoted to the water of crystallization.

By "water of crystallization" is meant water that is combined in some loose chemical way with the chemical of which the crystal is composed, and it does not mean the water adhering to a moist crystal. Thus, 47 per cent. of a perfectly dry crystal of alum consists of this water of crystallization.

The estimation of this water of crystallization is a very simple proceeding, all that is necessary being to heat a weighed quantity of crystals, first, on a water-bath, when it will be noticed the crystals liquefy, and then on a sand-bath, when the steam arising from the liquefied mass proves the presence of water. The heat being continued for a sufficient length of time, all the water will be removed, and a dried mass, known as the "exsiccated" salt, remains.

In the case of alum, 100 Gm. of the crystals dried with proper heat will leave but 53 Gm. of the exsiccated alum, showing that 47 per cent. of same is water. The amount of water of crystallization found in a given chemical is exactly the same for all perfect samples, and a study of the question has shown that the quantity of water in a crystal is in molecular proportion to the quantity of the substance, thus permitting the numeric expression of the amount of water in the chemical formula of the compound. (See p. 363.)

In this case, when we give the formula of sodium sulphate, $Na_2SO_4 + 10H_2O$, we can deduce therefrom the molecular weight, and are brought to the conclusion that in every 278 Gm. of crystalline sodium sulphate there are 180 Gm. of water.

We can deduce in the same way from the chemical formula of potassa alum, $KAl(SO_4)_2 12H_2O$, that this contains 47 per cent. of water of crystallization.

The term "water of crystallization" is gradually becoming obsolete, and instead we speak of the body containing such water as "hydrated." Thus, $Na_2CO_3 10H_2O$, is now called dekahydrated sodium carbonate, while the official form, $Na_2CO_3H_2O$, is called monohydrated sodium carbonate, and this term constitutes the pharmacopœial name of this salt. Recent research shows the difference between the dekahydrated and the monohydrated forms of the same substance can be easily explained by the rules of physical chemistry; hence, the term "water of constitution," formerly used to designate the last remaining water, is being dropped.

Interstitial Water.—Among the chemicals which separate in crystal form from aqueous solution, without the absorption of water of crystallization, the best known example is common salt. This separates in handsome masses of cubical crystals, and, in separating, it very frequently mechanically closes certain quantities of water which must be clearly differentiated from water of crystallization, because retained in a purely mechanical manner. Such water, which gathers in the interstices found in a mass of crystals, is called "*interstitial water.*" On heating a substance containing interstitial water the latter is converted into a steam which, on expanding, tears the crystal mass asunder with a crackling sound. This phenomenon, called *decrepitation*, is different from the deflagration of potassium nitrate, which is due to the liberation of oxygen.

Efflorescence and Deliquescence.—The crystals of some substances, sodium phosphate, for example, part so readily with water of crystallization that even at ordinary temperatures the latter dissipates, causing the crystal to fall into a white powder. This loss of water of crystallization at ordinary temperatures is the phenomenon termed *efflorescence*. Special attention should be paid to the fact that an effloresced body means one which has lost its water of crystallization and hence is stronger than the same body in the form of clear pure crystals. For this reason, in making a pharmaceutic preparation, care must be observed that, unless otherwise specified, the substance should be perfectly crystalline, and, if the effloresced salt is used in the same quantity as is directed for the crystalline, the finished preparation will be stronger than was intended.

Efflorescence, however, is not always loss of water of crystallization; thus when ammonium carbonate effloresces to ammonium bicarbonate, water of crystallization does not enter into the proposition (p. 455).

On the other hand, some crystalline substances have such affinity for water as to absorb same from the moist atmosphere, ultimately liquefying. Such substances are said to be "*deliquescent*," and a notable example of such deliquescence is the case of potassium acetate, which should, therefore, never be dispensed in papers.

Amorphous bodies and liquids which absorb moisture from the atmosphere in the same way are said to be *hygroscopic*. Thus, glycerin is a good illustration of a hydroscopic substance.

Efflorescence is now explained by physical chemists in terms of vapor tension of the hydrate. If kept in an open vessel, a hydrate having a higher vapor tension than that of water will lose its water of hydration and will therefore effloresce. Hydrates with a lower vapor tension will, on the other hand, remain unchanged. Thus, sodium sulphate, $Na_2SO_410H_2O$, at 9°C. has a vapor tension of 5.5 mm. Water, at 9° has a vapor tension of 5.0 mm. Copper sulphate, $CuSO_45H_2O$, at 9°C. has a vapor tension of 2 mm.

In accordance with the principle just expressed, sodium sulphate crystals will effloresce while copper sulphate crystals are stable.

It has been found that deliquescence is a property of those substances, the solutions of which, have a vapor pressure less than the vapor pressure of water vapor in air at the same temperature.

GRANULATION

Granulation is best defined as interrupted crystallization, while the operation of granulation is the process of heating a chemical substance with constant stirring until moisture is evaporated and a sabulous (coarse-grained) powder is produced. This definition, however, does not describe the manufacture of the so-called granular effervescent salts.

In granulation a substance is prepared as in crystallization, by separation from a supersaturated solution. As mentioned under Crystallization, to secure large and handsome crystals by this method it is usual to leave the hot filtered liquid perfectly quiet, a stirring of the same producing small, ill-defined crystals. As such is exactly the object of granulation, in that operation the hot filtered solution is stirred and the separation of the crystals facilitated by evaporation of the substance from the liquid to a point where a very small quantity of solvent remains.

In granulating a substance, however, the evaporation should not be continued until all the liquid has disappeared, as a certain quantity of mother liquor is essential to remove soluble impurities by solution in the mother liquor.

Chemicals in granular form have of late years become quite popular, due to the more rapid solubility of same than the larger crystals, following the statement made under Solution that the latter is facilitated by comminution of the dissolving substance.

Apparatus.—In granulation the only apparatus needed are those required for crystallization from saturated solution, viz., flask in which the solution is made, apparatus for the filtration, evaporating dish, and glass stirring rod. The operation itself will best be understood by preparing 20 Gm. of Granulated Ferrous Sulphate, U.S.P. (See Part VII.)

Granular Effervescent Salts.—This class of preparations is totally different from the true granular salts, such as granulated ferrous sulphate inasmuch as they are totally devoid of crystalline property, and are called "granulated," because consisting of the chemical in uniform and small particles.

All these preparations are so made as to contain tartaric acid and some carbonate, so that when mixed with water copious effervescence occurs (p. 418). Here need it only be said that the preparations are made by mixing the active chemical with the acid and the carbonate, moistening with alcohol, and running the moist mass through a coarse sieve, whereby it separates into small and regular particles. The reason the mass is moistened with alcohol is that alcohol renders same sticky without producing the chemical action between the acid and the carbonate which would result were they moistened with water. For the same reason these preparations must be kept in tightly stoppered bottles to prevent contact with moist air, which would soon render them no longer effervescent. These salts can also be granulated by softening the mass by heat of a water-bath and passing the soft mass through a sieve.

A general formula for effervescent salts, given in the National Formulary under the title, *Sales effervescentes*, is worthy of careful reading.

EXSICCATION

Exsiccation is the process of removing water of crystallization from a chemical by the use of strong heat. This process was foreshadowed on a preceding page (p. 150), so here it need only be added that the chief object of exsiccating a substance is to reduce its bulk. Thus, a crystal of alum weighing 10 Gm. contains but little less than 5 Gm. of water, and but little over 5 Gm. of the chemical itself, hence 5 Gm. of exsiccated alum represents the same strength as about 10 Gm. of the crystal. In most operations the exsiccated salt has but little value over the crystalline, and perhaps is even less useful, as we usually employ chemicals in solution, and an exsiccated substance is more difficultly soluble that is the same substance in crystalline form. Therefore the chief use of exsiccated substances is for incorporation in pills, the size of which should be limited to 5 grains, and by use of 5 grains of the substance, represent about 10 grains of the same body in crystalline form. This explains the employment of dried ferrous sulphate instead of the crystalline, in making pills of aloes and iron. The chemical, dried alum, has, however, therapeutic value not possessed by the crystals.

Apparatus.—The apparatus used in exsiccation consists of an evaporating dish, which should be tared, while the source of heat is usually a sand-bath. (For details of operation, see Exsiccated Alum, Part VII.)

DIALYSIS

Dialysis or *osmosis* is a process whereby the crystalline portion of a mixture is separated from the non-crystalline by the passage of the former through a permeable membrane. The crystalline substance which passes through the membrane is called *crystalloid*, while the non-crystalline substances, usually of mucilaginous character, are called *colloids*, from the Greek "*kolla*," meaning glue.

Diffusion, dialysis and osmosis are words used to indicate phenomena that are closely related. The term, diffusion, is usually applied to the mixing of adjacent layers of fluids or of gases, as obtains when alcohol is layered on water or when a heavy gas like carbon dioxide is passed into a cylinder containing air. Dialysis and osmosis, on the other hand, are used to indicate admixture by the passage of material through a porous membrane. Physical chemists now differentiate between dialysis and osmosis by applying the first term to the passage of the crystalloid solution into the water, and the word, osmosis, to the passage of water into the solution containing the crystalloid, for it is to be noted that both fluids pass through the membrane in opposite directions. This produces the phenomenon called *osmotic pressure* which is analogous to gaseous pressure and which like the pressure of gases can be expressed mathematically by equations in which one of the factors is the molecular weight of the substance studied. In fact, even as the molecular weight of gases can be deduced from their relative speed of diffusion, so, from the osmotic pressure of a solution can the molecular weight of the solute be determined.

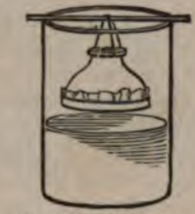
Fig. 157.—Dialyzer.

The process of dialysis was discovered by Graham in 1861, and at the time of discovery it was thought it would be of unlimited use in pharmacy and other arts. Experience, however, has shown that its value is largely theoretic; the study of plant and animal physiology proving that a large portion of the so-called vital processes going on in the living organism operates upon the principle of dialysis.

The apparatus used in dialysis consists primarily of any porous membrane. For this purpose a bladder is usually employed, although parchment paper or unglazed earthenware is employed for the purpose.

The rest of the apparatus consists of two containers of glass. The membrane is attached to a bottomless cylinder of glass or other suitable material, in such way as to serve as the bottom, and is made to rest upon the surface of water held in the second container, and upon the membrane is poured the liquid which is desired to be dialyzed (Fig. 157). This done, the crystalloids contained in the liquid on the dialyzer begin to pass through into the liquid below, whereas the non-crystallizable substance remains behind, thus affording a very simple method of separating the mixture of, say, sugar and starch, the sugar being crystalline, passing through the membrane, and the starch remaining behind.

Objects.—As mentioned above, the most important object of dialysis is in the natural processes of animal and vegetable economy. Some soluble solids pass from one section to another by the process of dialysis. In the pharmaceutic application of dialysis a class of preparations, called "dialysates," were put upon the market. These are usually made by placing a decoction of plants on a dialyzer and evaporating the crystalloid liquid. The latter contained the crystalline alkaloid, whereas the residue left on the dialyzer consisted of the usually inert colloidal substance. As examples of such preparations occasionally used may be mentioned dialyzed opium and dialyzed cinchona, but these preparations did not come up to first anticipations, and at the present time practically the only dialyzed preparation used to any extent in pharmacy is dialyzed iron, which is a colloidal preparation. (See p. 515.)

In chemistry dialysis is of some value in the separation of crystalloidal substances from obnoxious colloidal matter. This is particularly the case in toxicologic examinations, when searching for alkaloidal poisons; the latter can be separated from the stomach-contents by throwing the matter on a dialyzer and evaporating down the crystalloidal liquid. Even in this case, however, the application is somewhat limited because too slow, and other methods of separation are usually employed.

Colloids.—During the past fifteen years physical chemists have carefully studied that class of substances known as colloids and many puzzling points concerning the chemical behavior of these bodies have been now satisfactorily explained. Those desiring to study the subject are referred to the papers mentioned in the bibliography which follows.

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CHAPTER X

EXTRACTION

Under the head of Extraction are grouped the processes in which the active and soluble constituents of a drug are separated from the inert insoluble portion by the use of an appropriate solvent. These processes comprise maceration and expression, percolation, digestion, infusion, decoction.

In order to understand the principle underlying the process of extraction it is necessary to appreciate the structure of the ordinary vegetable drug. Any drug representing a plant part is comprised of a collection of cells, lately living or long dead, each one of which possesses a wall of more or less thickness, this wall consisting of some variety of cellulose, possibly lignin or suberous, corky tissue. The cell-wall is an insoluble thick envelop, scarcely permeable to liquid, while the active principles which we seek are generally found in the orifice encircled by the wall. To get the solvent in direct contact with the soluble constituents within the cell it is necessary that the cell-wall be ruptured, hence in extraction we must first comminute the drug. The cells in some drugs are larger than others, hence some drugs are directed to be powdered more finely than others in various pharmaceutic processes, the aim of the pharmacopœia being to reduce the powder to a fineness sufficient to insure the breaking of every individual cell.

The quantity of cell-wall, as compared to the amount of constituents, is usually many times greater. Thus, for example, in cinchona bark we find that but 5 per cent. of the total amount is alkaloids, and no more than 30 per cent. of the whole is soluble matter. Therefore the primitive method of administering the crude drug in powdered form meant the consumption, by the patient, of a large amount of not merely inert, but indigestible woody tissue, in order to get a small amount of medicament. To obviate the necessity of administering this large quantity of inert matter is the prime object of extraction, and in each case cited above it is accomplished by treating the drug with an appropriate solvent, and the removal, by solution, of the useful principles from the inert insoluble residue.

MACERATION

Maceration is the process of removing the active principles from a drug by allowing the latter to remain in contact with the solvent several days, with frequent agitation.

Roughly stated, maceration consists of reducing the drug to appropriate fineness of powder, placing same in a suitable bottle, pouring on the solvent, which is called *menstruum* in all cases of extraction, and letting the mixture stand for a week, shaking at frequent intervals. The solution is then removed from the inert matter by filtration or straining, and the yield of filtrate increased by subjecting the residue to expression.

The process of maceration is a favorite method of extraction in most European countries. In America maceration is used only where percolation is precluded, and it is, therefore, limited to the few drugs the gummy or viscid character of which would cause a clogging of a percolator. The German Pharmacopœia directs maceration exclusively in the manufacture of tinctures, and even in this country some of the older pharmacists still cling to the process of maceration in the preparation of a large number of tinctures, the advantages they claim for maceration being, first, that the drug need not be powdered as finely as in the case of percolation, second, that the process requires less skill than does percolation, and hence requires less care in manipulation, and, third, that in the process of maceration there is less loss of alcoholic menstruum than in making the same preparation by percolation.

The latter is practically the only advantage possessed by maceration over percolation, the other questions not being worthy of attention of the intelligent and educated pharmacist.

In large quantities of a preparation made by maceration, say, gallon lots, the shaking of the bottle containing the drug and menstruum is a laborious task, and since the shaking is merely to bring all portions of the solvent in contact with the drug, and as the same result can be obtained by the process of circulatory solution (p. 122), this method can be employed in the maceration of tinctures, the ground drug being placed in a cloth bag and suspended directly below the surface of the solvent.

As mentioned above, the inert residue remaining after maceration (which is called the *marc*) is impregnated with the same strength of tincture, and in filtering off a macerated tincture—say, of arnica—the residue on the filter is not wet with alcohol, but with full strength tincture. Hence, it can be seen that the process, even at its best, is wasteful; that the drug is never completely exhausted of its active principles, and the less care used, the more waste there is to the process. The waste is partly obviated by "squeezing the dregs," as we commonly say; by expressing the residue.

EXPRESSION

This is the process of removing the liquid from a moist mass by the use of pressure, one of the best illustrations of the application of expression being in the removal of the remaining tincture from the marc.

Apparatus.—Many forms of presses have been devised, each adapted for some special phase of expression.

All forms of presses, with the exception of forcible straining apparatus and the Enterprise screw press, consist of two plates between which the substance is placed, and which are made to approach each other by means of lever, screw, or some other mechanical power.

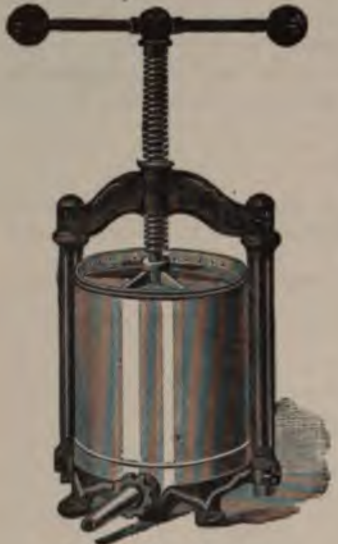

Fig. 158.—Tincture press.

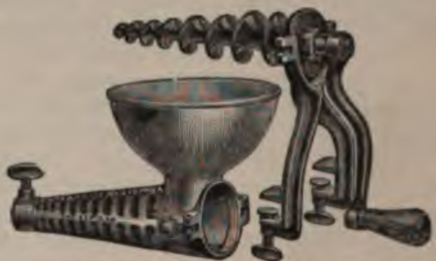

Fig. 159.—Enterprise press (opened).

Important in the process of expression is the straining of the expressed liquid through suitable cloth. We, therefore, usually inclose the mass to be expressed in a bag of stout cloth (press cloth) before placing it in the press. Such press cloth (strong toweling will do) can be used directly for expression, as already explained under Forcible Straining (p. 131).

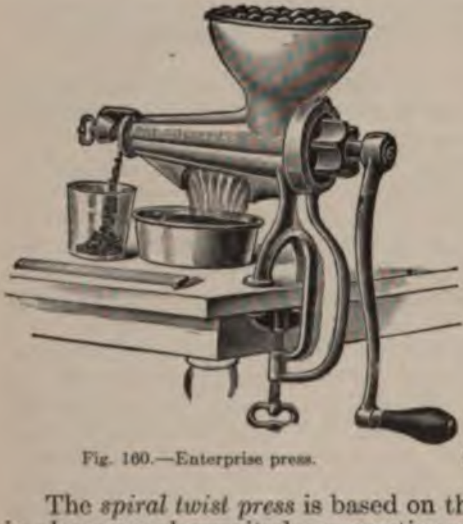

Fig. 160.—Enterprise press.

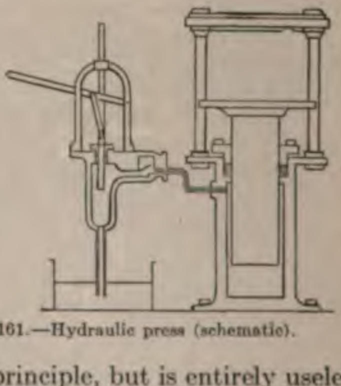

Fig. 161.—Hydraulic press (schematic).

The *spiral twist press* is based on this principle, but is entirely useless in pharmacy, hence its bare mention will suffice.

Other forms of presses of little pharmaceutic value, but used in other technical lines, are the *wedge press*, the *roller press*, which operates on the same principle as the roller clothes-wringer, and is seen in its form of highest perfection in the rollers used for expressing the juice from the sugar-cane, and the *hand-lever press*, in which the upper plate is pressed down upon the lower plate by means of a lever.

In modern pharmacy expression is performed with the *screw press* or tincture press (Fig. 158), in which the moist mass is subjected to pressure between two steel plates, the upper one operating on a screw, such as is seen in the ordinary letter-press. A very striking modification of the screw press is the *Enterprise press*, which will best be understood by an examination of Figs. 159 and 160. Of great value and increasing popularity is the *hydraulic press*, the only objection to which is its initial cost. This is constructed on that principle of hydrostatics which asserts that if a liquid be in communicating tubes—one larger than the other—any pressure on the surface of the liquid in the smaller tube will be exerted on the surface of the liquid in the larger tube in exact proportion to the relative size of the two tubes. This can be explained more clearly as illustrated in Fig. 161.

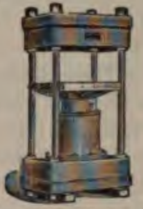
Fig. 162.—Hydraulic press.

Suppose, in this sketch, that the area of the cylinder A is 1 square inch, and that of cylinder B is 10 square inches; then, if we exert a force of 1 pound on piston "*a*," we will get a force of 10 pounds on piston "*b*." By using a lever on piston "*a*" we can so multiply the force that a pressure of 10 pounds on the handle of the lever connected with piston "*a*" can readily exert the pressure of 1000 pounds on piston "*b*;" hence the great value of the hydraulic press, with which comparatively little power can be concentrated into enormous pressure.

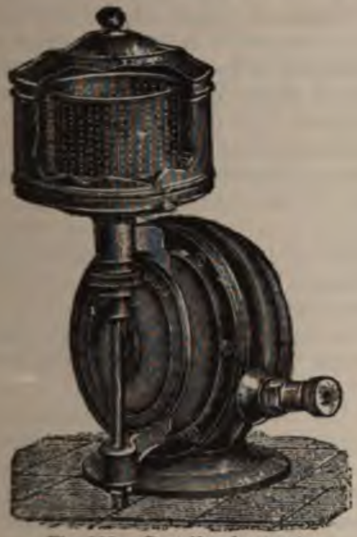
Fig. 163.—Centrifugal extractor.

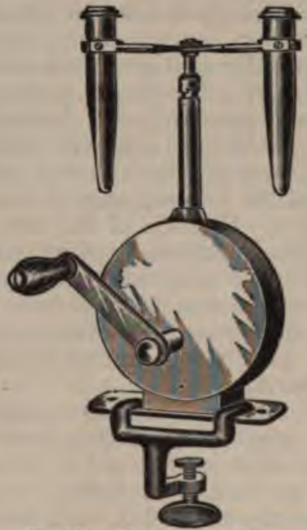
Fig. 164.—Urinary centrifuge.

An interesting form of removal of liquid from a moist mass without the aid of a press is the operation of the centrifugal machine, in which case the moist mass is placed in a perforated cylinder, which revolves in a large cylinder with velocity great enough to cause practically all traces of the liquid to be thrown out of the inner into the outer cylinder (Fig. 163). By means of such a centrifugal press 200 or 300 pounds of moist sugar can be centrifuged to almost dryness in the space of five or ten minutes. A modern application of the centrifugal machinery, totally different from expression, is the well-known centrifugal sedimenter, for the precipitation of blood and of urinary sediment (Fig. 164).

PERCOLATION

Percolation is the process of depriving a drug of its soluble constituents by passage of a solvent through the powder contained in a suitable vessel. The solvent in this case is called the *menstruum*, the vessel is called the *percolator*, and the solution of active principles emerging from the percolator is called the *percolate*.

History.—Lixiviation, the extraction of lye from ashes has been used since ancient times: Rumford devised the plan of making coffee in the drip coffee pot in 1813; Johnson (1817) extracted cinchona in an apparatus like Rumford's; Real used a percolator press for removing the oil from almonds; Boullay (1833) and Robiquet (1835) introduced the method and it was directed for some preparations of the French Codex of that year; Procter and Duhamel first described the process in this country and it was employed in the pharmacopœia of 1840, since which time it has been so much more popular in this country than in Europe that it can almost be considered an American process.

Principle of Operation.—Careful study of the definition of percolation will show that in the process advantage is taken of the attraction of gravitation, for it is hardly necessary to say that a liquid poured on top of a powder contained in a suitable utensil will gradually penetrate that powder in a downward direction, and if there is an orifice in the bottom of the vessel, the descending liquid will emerge from the vessel, being attracted by gravity toward the center of the earth. This downward force of gravitation is aided by another force, merely a modification of the former, namely, the weight of the column of liquid above the powder. Mention of the latter is made here merely because the downward force varies according to the height of the column of liquid, whereas the force of gravitation remains unchanged. If this combined action of gravitation was the only force coming into operation, the process would be a simple one. However, there is an opposing force which comes into play during the process of percolation, namely, the upward force of capillarity.

The term *capillarity* comes from the Latin term "*capilla*," meaning hair, because it was first observed that in every narrow, hair-like tube liquid was drawn up by the cohesive power of the walls of the tube, and, as already explained, to this same force is due the appearance of the meniscus (p. 47). All bodies possessing orifices more or less narrow have this property of drawing up liquids by their own cohesive force, and such is eminently the case with most vegetable drugs, since, as is mentioned above, they consist of a mass of cells, each cell consisting of an orifice of more or less fineness, surrounded by a cell-wall. In other words, cells can be compared to long sealed tubes, and when the cells are broken by powdering, we have a vast mass of tubes, each possessing capillary attraction. This capillarity explains why a so-called porous substance, for example, a sponge, will absorb so much more water than a non-porous substance, such as sand.

To get back to percolation, besides the force of gravity and its modification, the pressure of the column of liquid above, forcing the solvent downward through the drug, we have at the same time capillarity of the cells of the drug attracting the menstruum in the the opposite direction. The moment the solution commences to emerge from the vessel, the capillary attraction of the cells tends to keep the liquid within the substance; therefore, acting against the force of gravity. Experience shows that the capillary force of the drug is usually greater than the simple gravitating force of the earth, for unless the gravitating force of the earth is reinforced by the height of the column of liquid above the powder, the liquid ceases to drop from the percolator. As the liquid passes through the drug on its downward course it penetrates the interior of each cell (provided the substance is in fine enough powder) and removes from the same the soluble constituents. Passing from one series it penetrates the next tier of cells, and, taking up more active principle, such solution continues until the solvent is saturated with the soluble principles of the drug. When once a saturated solution, it mechanically passes through the rest of the drug, and finally emerges from the orifice of the bottom of the percolator, providing always that there is a sufficient column of the liquid to force it down. Its passage is followed by a fresh portion of the solvent, which passes through the same cells which it has formerly penetrated, removing the last vestiges of soluble matter, and finally emerging from the percolator also a saturated solution. In this way menstruum is continually poured on until the cells have been so completely exhausted of their soluble constituents that the final portion of the menstruum comes through devoid of color and taste, whereupon the drug is said to be *exhausted*.

The great advantage percolation possesses over maceration is in the fact that, by means of percolation, we are enabled to completely remove every trace of soluble matter from a drug, inasmuch as the saturated solvent does not remain in contact with the drug (if the menstruum column is maintained), but passes from it, being followed by a fresh portion of solvent, which removes the remainder of the soluble principle.

Apparatus.—The utensil in which the drug is packed is called a *percolator*, and consists of a suitable cylindric vessel of metal or glass, provided with an orifice at the bottom. In selecting a percolator those of glass should be chosen when possible, metal percolators having the double disadvantage of being more easily attacked by acid or other substance which the menstruum or drug may contain and also the fact that their opacity prevents watching the operation. Of course, however, there are certain limits to the size of a glass percolator, the writer's experience being that the use of a glass percolator larger than two gallons is an expensive luxury, inasmuch as such are costly and are quite liable to break. Above two gallons, recourse was had to the galvanized iron percolator or the well tube percolator, in which the container is an earthenware crock.

Shape of Percolators.—The simplest form of percolator is the conic (Fig. 165), consisting of an ordinary chemical funnel. This, however, offers too great a width of surface for the menstruum, which, therefore, has a correspondingly smaller course to travel before emerging from the bottom of the percolator, and, therefore, the familiar tapering percolator came into use (Fig. 166). At the present time the Oldberg cylindric percolator (Fig. 167) is very popular, for by means of it we are able to exhaust a drug far more thoroughly than in either a tapering or a conic percolator, from the simple fact that each portion of menstruum has to travel through a larger amount of the drug before emerging from the percolator. A variety of percolator used exclusively in chemistry is the Soxhlet Extractor (Fig. 168). The Landsiedl modification of the Soxhlet is arranged with a set of special extracting thimbles, which permit the use of the apparatus for extraction of aqueous solutions with immiscible solvents.

The saturated solution, when emerging from the percolator, is called the *percolate*, and, of course, this must be collected in an appropriate vessel. For this purpose a wide-mouthed bottle, the receiving bottle, is usually employed. Elaborate forms of receiving bottles are on the market in which the graduations are engraved upon the glass. These, while presenting an elegant appearance, are scarcely necessary, as the pharmacist has many wide-mouthed bottles at his disposal, and he can usually graduate same by pouring in definite quantities of liquid from an accurate graduate, and marking amount by cutting with a file or on a strip of paper pasted along the length of the bottle (marking same with ink). The percolator must be supported on an appropriate stand, and for this purpose nothing can be better than the retort stand pictured in Fig. 83, it being always understood, however, that the glass percolator must never come in contact with the iron ring, being protected from the same by covering the ring with paper or cloth (Fig. 169).

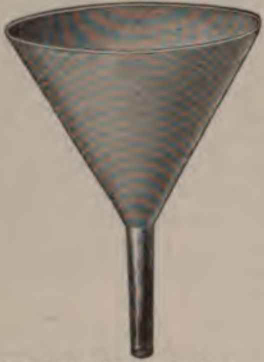
Fig. 165.—Conic percolator.

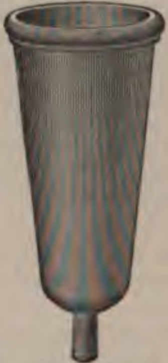
Fig. 166.—Tapering percolator.

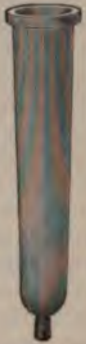
Fig. 167.—Oldberg percolator.

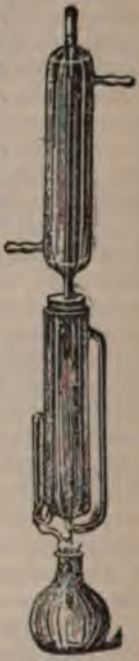
Fig. 168.—Soxhlet extracting apparatus.

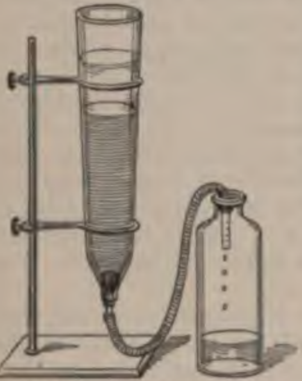
Fig. 169.—Correct percolation.

When large amounts of percolation are being carried on, special percolating stands have been devised; such, for example, as the Shinn percolating closet and the Remington percolating shelf.

Operation.—The process of percolation may be divided under the following headings: Comminution of the drug; moistening the same; packing in percolator (with maceration either before or after packing); pouring on the menstruum and collecting percolate until exhausted.

Comminution.—Before percolating the drug it is essential that it be reduced to particles of more or less fineness, for the same reason that we comminute drugs before solution. As mentioned above, in percolation it is essential that the drug be ground sufficiently fine to rupture all the cells of which it is composed, and this degree of fineness is dependent upon the structure of the drug, those drugs having small cells calling for a finer degree of comminution than those in which the cells are large. Thus, nux vomica must be powdered very finely, whereas in gentian the cells are large and a coarse powder can be utilized. This explains why the pharmacopœia directs various degrees of fineness for the powders used in percolation. Another point regarding comminution of the drug is the rapidity or completeness of exhaustion. Thus, in percolating fluidextracts it is usually desirable to exhaust the drug with less menstruum than in preparing tinctures from the same drug, and in order to do this the drug used in percolating a fluidextract is generally directed to be in finer powder than that used in making the tincture. The powdering of the drug is accomplished by those methods of comminution described in Chapter VI. best serving the particular purpose, the main requirement being that the drug used in percolation be of uniform fineness.

Moistening of the Drug.—Before packing the drug in the percolator it is directed to be moistened with menstruum, this being done because, when the drug comes in contact with the menstruum, the compressed dried cells are swollen to their normal size, and if this swelling occurred within the percolator, it would cause sufficient expansion to cause a stoppage of the operation.

This moistening is accomplished by placing the drug in a suitable container, preferably of porcelain or stoneware, adding the required quantity of menstruum, and mixing same thoroughly with the drug by stirring with a wooden paddle. After being moistened it should be allowed to remain for half an hour in order to complete the swelling, thereupon the pharmacopœia directs the moist drug to be passed through a coarse sieve, thus making the product into a coarser granular powder, ready for packing.

Packing of the Drug.—To receive this granular powder the clean and absolutely dry percolator is prepared by placing in its neck a plug of absorbent cotton, followed by a layer of clean dry sand. This latter precaution was directed in former pharmacopœias, both for the purpose of filtration and also to hold the plug of cotton in place. Many careful pharmacists, however, omit the sand as an unnecessary detail. Upon this sand the granulated powder is poured in comparatively small quantities, the usual rule being to place in the percolator about one-fourth at a time, and each fourth is carefully and firmly packed before the next portion is added. The packing is accomplished by means of a wooden plunger, and for this purpose a piece of wood will suffice, there being nothing better than a wooden potato-masher. The packing of the drug is a matter of skill, and in order to do it successfully it is necessary to know the character of the drug and the menstruum. Drugs in finer powder are not, as a rule, packed so tightly as those of coarser powders, but the supreme test of the correct packing is the rapidity of the flow of the percolate. If the drug is packed too tightly, the percolate drops too slowly, and if too loosely, the percolate runs so rapidly as not fairly to exhaust the drug; therefore, packing must be put down as chiefly a matter of experience. The nature of the menstruum also has an influence on the packing of the percolator. If the menstruum is pure alcohol, the drug can generally be packed more tightly than if it consists of water, and if glycerin is present in the menstruum, care should be taken not to pack the drug too tightly. It is hardly necessary to say that in packing the drug the pressure should be equal on all sides of the powder. If the drug on one side of the percolator is packed more loosely than on the other, it stands to reason that the menstruum will choose the easiest possible way and will run down the looser side, and, therefore, the drug will be incompletely exhausted.

All the drug being packed in the percolator, there is carefully placed above it a sheet of filter-paper which is held in place by a glass weight, any unused glass stopper answering the purpose. The object of the paper is to prevent the disturbance of the powder when the menstruum is poured in, the force of the fall of the liquid being apt to cause the rising of the powder to the surface of the menstruum.

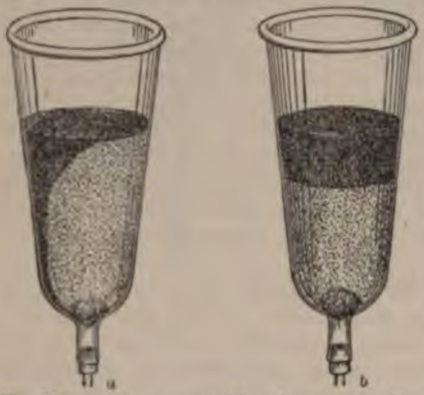

Fig. 170.—*a*, Improper packing; *b*, proper packing.

Instead of filter-paper, the writer found very convenient disks of ordinary clean Manila card-board, made from one of the many rejected paste-board boxes found in every drug-store. These disks, perforated by the point of a file, when just the size to fit snugly above the drug within the percolator, required no weight to keep them down.

Whether the drug has been packed evenly on all sides is shown by the descent of the first menstruum, which should go down in a perfectly even ring, as shown in Fig. 170, *b*.

After the drug is packed in the percolator and enough menstruum has been poured in to fully penetrate the drug and to begin dropping from the percolator, the lower orifice is closed and the drug is directed by the pharmacopœia to macerate within the percolator for a period ranging from twelve to forty-eight hours. Many prefer to macerate the drug for a period of twenty-four to forty-eight hours before packing in a percolator, as in this case the maceration can be conducted in an absolutely closed vessel or a well-stoppered bottle.

Adding Menstruum.—The menstruum is, as mentioned above, the solvent used for extracting the active principles of the drug. The various menstrua directed by the pharmacopœia for different drugs have been carefully selected with a view to using the particular solvent best adapted easily and speedily to remove the active principles of the drug under consideration. In some cases, however, the pharmacopœial committee has been guided by practical commercial considerations, the rule being to choose as menstruum the cheapest solvent that will fully answer the purpose. Understanding this fact, the pharmacist should carefully follow the pharmacopœial instructions, appreciating that when the United States Pharmacopœia directs strong alcohol, it is because a weaker alcoholic menstruum will not answer the purpose.

Usually the menstrua used in percolation are of various mixtures of alcohol and water; occasionally glycerin is directed to be added to the menstruum, this usually in cases of drugs containing large quantities of tannin. In the same way ammonia water is added to the menstruum in preparations of licorice, and ammonia or other alkalis for drugs containing pectin, while acids are used in the menstrua for drugs containing volatile alkaloids, such as conium, ergot, etc.

Not all percolates are made with alcoholic menstrua; for example, some infusions are made by percolation of the drug with water;—infusion of cinchona (U.S.P. 1890) with water plus aromatic sulphuric acid, and infusion of wild-cherry (U.S.P. VIII.) with cold water.

Again, stronger white wine was used as a menstruum in the preparation of percolated wines of the pharmacopœia of 1890. Dilute acetic acid is used in those vinegars made by percolation, while oleoresins are made by percolating the drugs with ether or acetone.

The Percolation.—The proper menstruum is poured upon the filter-paper above the powdered drug in the percolator, care being taken to pour it so as not to cause the floating of the paper. As the menstruum passes down through the drug, more is added to take its place, it being an unvaried rule that there should always be maintained a layer of menstruum above the surface of the drug, for, if the drug is exposed to the air, evaporation takes place from its surface, and fissures occur through which the menstruum added afterward will run, instead of through the entire surface of the drug. In order to keep a sufficient quantity of menstruum upon the surface of the drug, recourse is had to continuous percolation by inverting the menstruum bottle within the percolator in the same manner as suggested in continuous filtration (Fig. 171). The menstruum poured in and passing through the drug should emerge from the percolator slowly and steadily, the rapidity being dependent entirely upon the quantity of the drug being manipulated; thus the last pharmacopœia directs a flow of ten drops a minute in percolating 1000 grammes of drug for fluidextract, while for tinctures the flow is to be twenty drops a minute. It is needless to say, however, that this standard would be absurd if we were percolating 200 pounds of a drug and expecting, say, 100 gallons of the percolate.

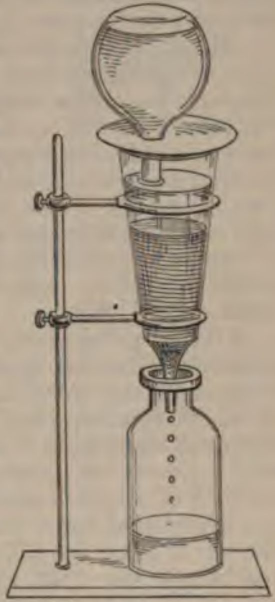

Fig. 171.—Continuous percolation.

In most operations in retail pharmacy, however, in which we deal with 200 to 1000 mils of menstruum, the speed given above may be maintained, and a skilful operator aims to so pack his drug as regularly to attain this speed, and after some practice usually learns the art. In order, however, to insure the speed of percolation directed, the pharmacopœia directs that the lower orifice of the percolator be closed with a cork through the perforation of which passes a glass tube which is fitted with a rubber tube, at least as long as the percolator and terminating with a second glass tube bent in the form of a "V." When the rubber tube is raised so that the outlet is above the surface of the menstruum in the percolator, it follows that no liquid will run out, whereas if it is lowered to its greatest depth, the liquid will run out very rapidly, and, by raising or lowering the tube to its greatest height or greatest depth, the rapidity of the percolation can be regulated to a nicety. If it is desired to close the tube completely, a pinch-cock (p. 98) can be used, although if the tube is of sufficient length, this is scarcely necessary.

In practice, the rubber tubing is not so convenient as it seems at first blush, as the several joints of the cork, the glass tube, and the rubber tube fittings are apt to leak unless very carefully prepared, making an unsightly and dirty process. If, therefore, the percolating tube is used, care should always be taken *before percolation* to see that the cork and rubber tubes do not leak by pouring water into the empty percolator, raising the tube to its greatest height, and allowing it to stand in that way for some time.

Many pharmacists omit the use of the rubber tube, substituting therefore an ordinary cork with notches in the side, which do not extend through the entire length. If the percolation is desired to be stopped, the cork is pushed up into the neck beyond the notch, when an absolutely water-tight fitting occurs. When the flow is desired, the cork is loosened so as to allow a part of the notch to be beyond the neck of the percolator, leaving a tiny orifice through which the liquid can be dropped. This scheme is usually satisfactory, although the tightening and loosening of the cork during the process of percolation are apt to be untidy. Far better, therefore, is the use of a metal sprinkler top, such as is used for tooth-wash bottles.

Finishing Percolation.—By making preparations by percolation it is generally intended that the percolation be continued until the drug is exhausted, the word meaning in this case the removal from the drug of all its soluble constituents. There are several ways of proving the practical exhaustion of a drug, for, in the operation, it is usually unnecessary to carry on percolation to the extreme point of removing every particle of soluble matter. If the drug is a bitter one, we generally say it is exhausted when the percolate comes through no longer bitter, even though it may be still impregnated with some of the coloring-matter residing in the drug, the latter being more tenacious and persistent of removal. In some cases the bitterness is so great that a large amount of menstruum will be necessary before every trace of bitterness is removed. An example of this is quassia, in which case we generally consider the drug exhausted when the percolate is almost free from bitterness.

Tannin-bearing drugs are usually percolated until the percolate is free from astringency, whereas in odorous drugs the absence of odor from the percolate announces exhaustion.

The residue left after percolation or maceration is called the *marc*, and in both percolation and maceration it retains a considerable amount of moisture. As mentioned under Maceration, in the latter case the moist liquid is the finished full strength tincture, and this marc should always be expressed, else the yield of tincture will be lessened. In percolation the marc is moist with the menstruum, hence there is no loss so far as finished tincture is concerned, but the loss of menstruum is excessive. It, therefore, behooves the economic pharmacist to recover the alcohol from this marc, which can be done by the process of steam distillation. During the writer's experience in practical pharmacy it was his custom to keep on hand a number of half-gallon wide-mouthed candy jars, securely corked, and in these he threw the successive batches of marc at the end of every percolation. When sufficient quantity had accumulated in these bottles, his steam distillation apparatus was fitted up, the tube from the boiler fitted into the candy bottle, and steam passed through and the vapors collected. The yield of alcoholic distillate more than paid for the fuel and time employed.

This process is found more convenient and efficacious than the ordinary method of pouring water on the drug, and thus forcing the menstruum out, as in the latter case the addition of water to the starchy matter remaining in the marc is apt to cause a swelling of the drug and subsequent clogging of the percolator.

Modified Percolators.—Under Distillation and Comminution we found that ingenuity had devised many special apparatus for carrying on both operations, and the same also holds good in regard to percolation.

Chief among these improved forms of percolators must be mentioned the Squibb's well tube percolator (Fig. 172), which is primarily designed for the percolation of large quantities of drug. As mentioned above, under the consideration of the percolator itself, glass or earthenware percolators larger than two gallons are inconvenient to handle. Therefore, in large manufacturing establishments recourse is had to either huge metal percolators or to percolators made of wood. Metal percolators are not advisable, for acids from the drug or menstruum may attack the metal and render the product liable to contamination by metallic contact, while wooden percolators, even if unobjectionable from the standpoint of contamination, becoming saturated from contact with an alcoholic solution of a certain drug, can be used for the percolation of that drug alone, and, therefore, in their use a separate percolator must be provided for each drug desired to be percolated. The chief cause of the frailty of glass or earthenware percolators is their funnel form, which also increases their cost. Earthenware crocks with flat bottoms can be obtained of almost any size and for prices comparatively low, and, possessing a firm foundation, are very durable; hence the use of same in percolation was suggested to the fertile mind of Dr. Squibb, whose experiments brought forth the well tube percolator, which consists of an earthenware crock with the

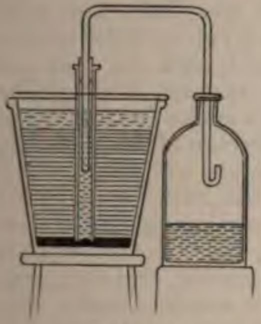

Fig. 172.—Squibb's well tube percolator.

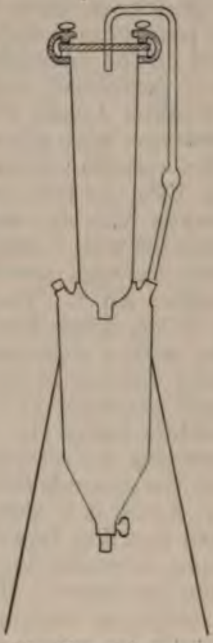

Fig. 173.—Economic percolator.

inside bottom fitted with a sheet of felt for filtering purposes, and the drug packed therein around a large glass tube. If, upon the drug so packed, menstruum is poured, it percolates through to the felt, then rises in the interior of the central glass tube to practically the same height as it is on the outside, following the well-known law of water seeking its own level.

Now, if in this tube is placed a syphon, the liquid within the well tube can be drawn off, and if a sufficient quantity of menstruum is kept on drug outside the well tube, a constant level can be maintained in the well tube ready to be drawn off through the syphon. In order to maintain a constant flow from the syphon its lower end must be bent up as shown in cut, making the orifice at least three-quarters of an inch higher than the orifice of the short arm. If this precaution is not taken, the liquid in the well tube is syphoned off more rapidly than it percolates, emptying the syphon immediately (Fig. 172).

Among the other forms of modified percolators are the various pressure percolators, such as Rosewater's and Berry's, both of these being based on the principle of the Real percolating press. With these, drugs can be percolated very rapidly and quite thoroughly.

Volatile Liquid Percolators.—In the manufacture of oleoresins by percolation with ether care must be taken to avoid undue evaporation of the volatile solvent, and in this case a special variety of percolator (Fig. 173) has been suggested. A similar volatile liquid percolator can be made with any ordinary percolator by fitting the lower orifice of the percolator with a cork, through which passes a glass tube, which in turn passes through another cork tightly fitted into the receiving bottle (Chapter XV.). Then there must be an exit for the air from the receiving bottle, hence the receiving bottle must have two orifices, one provided with a glass tube connected by a rubber tube to the cork, tightly closing the top of the percolator; which cork, for convenience sake, is usually provided with a second orifice, through which passes a funnel for the admission of the solvent. In some works the use of the rubber tube connecting the receiving bottle with the top of the percolator is objected to on the grounds that the vapors of ether will attack the rubber of this tube, hence it is recommended that the outlet tube of the receiver be drawn to a fine, tapering point, to reduce loss of evaporation to the menstruum, a similar tapering tube being fitted in the cork closing the top of the percolator. The author's experience, however, has shown that the danger of destroying the rubber is scarcely worth considering, and not only by means of such rubber tubing is the loss by evaporation reduced to the minimum, but a steady flow of air from the receiving bottle to the top of the percolator ensues.

A modification of a volatile liquid percolator was used by the writer in a long series of experiments in ordinary percolation, from which he drew the conclusion that it would be highly profitable to use such a volatile liquid percolator for all cases of percolation.

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PART II

INTRODUCTION

GALENIC PHARMACEUTIC PREPARATIONS

Having considered all the processes used in pharmacy, we are now ready to study the application of these in the manufacture of pharmaceutic preparations.

For convenience in teaching we group pharmaceuticals into two classes—*galenic preparations* and *chemical preparations*. Those preparations in the manufacture of which no chemical action is involved are called galenic, after Galen, one of the ancient medical authorities, while chemical preparations are those in which a chemical change is produced during process of manufacture.

Already, in discussing Solution (p. 118), attention was called to the fallacy of the grouping into simple and chemical solution, from the strictly philosophic standpoint; yet, at the same time, the convenience of such grouping from the pharmaceutic point of view is readily admitted.

The same reasoning applies to a certain extent to the grouping of pharmaceuticals into galenic and chemical preparations, for many so-called chemical preparations can be made equally well by the retail pharmacist by purely galenic means. Thus, while the manufacture of syrup of hydriodic acid of the pharmacopœia of 1890 involved a chemical action, the recipe of the present pharmacopœia consists in merely mixing diluted hydriodic acid with water and syrup. It is true that in making diluted hydriodic acid (U.S.P. IX.) the same chemical action occurs that took place in making syrup of hydriodic acid (U.S.P. 1890), but this does not apply as far as the present syrup is concerned, it being just as much a galenic as is syrup of citric acid.

As above mentioned, the classification of pharmaceuticals into galenic and chemical preparations, as far as this book is concerned, is a matter of convenience.

It would be manifestly absurd to discuss the manufacture of a preparation of which the most prominent feature is a chemical reaction, before considering the subject of chemistry as outlined in Part III.; hence in all such preparations the discussion of their manufacture will be deferred until Part III. is reached, and the only mention of them in this division will be the grouping of them under the heading Chemical Preparations in the list of officials found at the beginning of the discussion of each group of official pharmaceuticals.

The groups of official pharmaceuticals are given below in a tabulated form:

LIQUID PREPARATIONS

I. Solutions of volatile substances:

Aqueous	*Waters.*
Alcoholic	*Spirits.*

II. Solutions of non-volatile substances:

(*a*) Made by a simple solution:

Aqueous	*Solutions.*
Aqueous (viscid)	*Mucilages.*
Aqueous (saccharine)	*Syrups.*
Mellifluous	*Honeys.*
Alcoholic	Some *tinctures*, as tincture of ferric chloride.
Alcoholic (saccharine)	*Elixirs.*
Glycerinic	*Glycerites.*
Ethereal	*Collodions.*
Oleaginous	*Oleates.*

(*b*) Made by maceration or percolation:

Aqueous	*Infusions* and *Decoctions.*
Alcoholic	*Tinctures* and *Fluidextracts.*
Vinous	*Wines.*
Ethereal	*Oleoresins.*
Acetous	*Vinegars.*

III. Liquids containing undissolved matter:

(*a*) For internal use:

Aqueous, with neither oil nor resin	*Mixtures.*
Aqueous, with oil or resin	*Emulsions.*

(*b*) For external use:

Oleaginous	*Liniments.*

SOLID PREPARATIONS

I. Made by maceration or percolation:

By evaporation	*Extracts* (*Abstracts*, U.S.P. 1880).
By precipitation	*Resins.*

II. Without maceration or percolation:

(*a*) For administration by mouth in undivided portions:

Pulverized	*Powders.*
Semisolid	*Masses.*
Semisolid (saccharine)	*Confections.*

In divided portions:

Globular doses	*Pills.*
Disk-like doses	*Troches.*

(*b*) For administration by rectum, etc ... *Suppositories.*

(*c*) For external administration:

Greasy masses—	
Applied as a plaster	*Cerates.*
Applied by inunction	*Ointments.*
Moist masses	*Cataplasms.*
Sticky masses	*Plasters.*
Spread on or absorbed by paper	*Papers.*

CHAPTER XI

WATERS AND SPIRITS

WATERS

WATERS are *aqueous solutions of volatile substances,* not like spirits, which are alcoholic solutions of volatile substances; not like solutions, which are aqueous solutions of non-volatile substances.

Again, the volatile substance may be solid, liquid, or gaseous. An example of an official water containing a volatile solid is found in camphor water; among those containing volatile liquids may be cited any of the official waters made from a liquid oil.

The following table gives a list of official waters grouped according to process of manufacture:

TABLE OF OFFICIAL WATERS

Process.	*Galenic Preparations.*	*Chemical Preparations.*
Simple solution or dilution	*Ammonia water.* *Bitter almond water.* *Creosote water.* *Chloroform water.* *Orange flower water.* *Rose water.*	
Gaseous solution		*Stronger ammonia water.* *Chlorine water* (U.S.P. 1890).
Filtration through absorbent powder	*Anise water.* *Camphor water.* *Cinnamon water.* *Fennel water.* *Peppermint water.* *Spearmint water.*	
Distillation	*Distilled water.* *Hamamelis water.* *Stronger orange flower water.* *Stronger rose water.*	
Sterilization	*Sterile distilled water.*	

The process of preparing by *simple solution* or *dilution* consists in taking the constituent and adding and agitating same with a sufficient quantity of water. With those prepared by *gaseous solution* the gas is generated in an appropriate apparatus, and, after being washed, is passed into the cylinder containing the water, as explained on p. 127, usually the passage of the gas being continued until the solution is saturated with gas.

Some gases are much more soluble in water than others. Thus a 28 per cent. aqueous solution of ammonia gas can be prepared, while a saturated chlorine water contains only 0.4 of 1 per cent. of that gas.

Filtration through Absorbent Powder.—This process is employed to obtain a saturated solution of volatile oil, the only exception being the manufacture of camphor water, which see. Volatile oils are very sparingly soluble in water, and, in the attempt to facilitate solution, the oil is separated into a finely divided form by trituration with an absorbent powder, and when thus absorbed (p. 135) water is gradually added. The absorbent powders employed for this purpose in former pharmacopœias were magnesium carbonate and precipitated calcium phosphate. Waters prepared with either one of these powders are unsatisfactory. Magnesium carbonate dissolves in water in appreciable amounts, and an aromatic water prepared in this way will very frequently precipitate chemicals one desires to dissolve therein. Calcium phosphate was chosen by the pharmacopœia of 1890 by reason of its supposed insolubility; but investigation showed that while calcium phosphate is not so soluble as magnesium carbonate, the minute traces which do dissolve cause more mischief than does the magnesium carbonate; the calcium phosphate acting as pabulum for the spores of microscopic plants which may lodge in the water, forming flocculent, slimy masses, due to the growth of these spores into plants. For this reason, in the present revision, purified talc is chosen as the absorbent powder.

Distillation.—This process was the first way in which aromatic waters were prepared, and yields the finest product. The process of distillation has been fully described in Chapter V., and here need only be mentioned the modifications of the process adapted for the product under consideration.

The substances from which the volatile principles are to be obtained are suspended in a boiler or a still, and are never permitted to lie on the surface of the boiler next to the flame, for in such a case the heat produces a decomposition, and the product will be ruined through presence of empyreumatic odors. Into the still a requisite quantity of water is poured and is heated on a slow fire, and, as the vapors rise from the boiler, they carry with them the aromatic principles found in the plant. If enough of the substance is used, a considerable excess of the oil may be found floating on the surface of the distillate. In fact, most distilled waters are made on a large scale as the side product in the distillation of volatile oils (see p. 739).

Distilled rose water and orange flower water of commerce are termed simple distilled, double distilled, triple distilled, or quadruple distilled, according to strength.

A double distilled water is prepared by mixing 1 part of flowers with say, 2½ parts of water, and collecting 2 parts of distillate; triple distilled is made by distilling off 1 part of distillate from 1½ parts of flowers; while quadruple distilled is made by securing 1 part of distillate from 1 part of flowers; hence the triple distilled is stronger than the quadruple distilled. In some cases, in preparing quadruple distilled water, another 1 part of flowers is mixed with sufficient double distilled water, and 2 parts distillate obtained. This process of redistilling is called *cohobation*.

In most of the modern perfume factories the distillation over a naked fire has been supplanted by distilling in steam. In this case steam is passed into an appropriate iron vessel containing the aromatic substance, and in passing through it carries the odor along with it.

The preservation of distilled waters is not an easy matter by reason of the fact that such solutions afford a nidus for the growth of microscopic plants. It has been observed that the growth of these plants is furthered by the corking of the containers, and in the warehouses of the large aromatic water distillers the waters are kept in carboys, which are closed with a pledget of cotton instead of being corked.

The term "aromatic waters" has reference to that class of waters which are made from odorous principles, and are used chiefly as perfumes and flavorings. This includes all the official waters except the ammonia waters, creosote water, chloroform water, hamamelis water, and chlorine water (U.S.P. 1890).

Two methods of manufacture of aromatic waters not given official sanction are by *solution in hot water* and by *percolation through cotton.*

Hot-water Process.—This consists in agitating volatile substances with *hot water,* a process recommended by several pharmaceutic writers. The process, however, is not official, and the pharmacopœia has been wise in omitting the same, for the reason that the use of hot water occasions considerable loss through the evaporation of the volatile substance. Again, it may be cited that the use of hot water does not produce more saturated products; experiments have shown that when the waters so prepared are brought to the normal temperature and filtered until perfectly clear, their strength is no greater than those made by other processes. As a possible advantage of the use of hot water it has been said that the process afforded more rapid solution than any other process. But, admitting this as true, it is more than counterbalanced by the inconvenience of agitating a hot bottle with the possible blowing out of the cork, to say nothing of the danger of fracturing the glass container.

Percolation through Cotton.—The pharmacopœia of 1880 adopted the plan suggested by W. S. Thompson, of subdividing the oil by pouring it on absorbent cotton and picking the cotton into shreds. In this way a small quantity of oil can be distributed thoroughly over a considerable amount of cotton, and thus become intimately subdivided, strands of cotton acting as capillaries and drawing into the lumen minute traces of the oil. The process yields a very good and permanent product, but was abandoned in the revision of 1890 by reason of the untidiness of the operation, the pulling of the cotton usually being accomplished by hand. A modification of this process, the principle of which is the same, is that of dropping the oil drop by drop on a large sheet of filter-paper, and finally tearing the paper into shreds and digesting it in water, but this process is scarcely more advantageous than is the picking of cotton. The cotton on which the oil has been divided is then placed in a percolator, the neck of which has been plugged with a piece of pure absorbent cotton, and the cotton, imbued with oil, is then packed down firmly, and the water is made to percolate through the same. It must be said, in passing, however, that this process does not yield so strong a product as does the filtration through absorbent powder. And, in truth, none of the processes yields a more superior product in any way to the water prepared by pouring the oil into cold water and agitating from time to time during a period of twenty-four hours. Water so treated is separated from the undissolved oil by passing through a well-wetted filter.

It will be noted that the present pharmacopœia gives permission to prepare aromatic waters, either by the use of "Kieselguhr" by the filter-paper process, by shaking the oil with cold water, or by distillation under the special heading—*Aquæ aromaticæ.*

Special Notes on Official Waters.—Before discussing the several official waters, a few words explanatory of the order of presentation of these and other galenic preparations may not come amiss. Having already given the general methods of manufacture and a table of the official representatives of this class of preparations, at this place reference need only be made to the individual peculiarities of each of the several preparations, which will be presented in alphabetic order, except in cases where other arrangements are advisable. The official recipe for many of the same class of galenics is identical, save the constituents, and, therefore, in order to avoid "vain repetition," the pharmacopœial recipes will be given at length only in one case, and under the other preparations made by the identical process will be the reference to the typical recipe, with a note as to the deviations in making the preparation under consideration. To be specific, in the class of aromatic waters the six official waters—anise, camphor, cinnamon, fennel, peppermint, and spearmint—are made by exactly similar process, filtration through the absorbent powder (purified talc), the only difference being the employment of the specific oil (or alcoholic solution in one case) needed to make the particular flavor desired. Hence an outline of the U. S. P. recipe will be given in case of anise water, and in discussing the other five waters reference will be made under "recipe" to the anise water recipe, with such changes as are necessary to produce that special official. If no recipe is prescribed by the pharmacopœia, mention of the fact will be given.

Again, as already mentioned, Part II. is not the proper place to discuss the chemistry of manufacture of such official preparations as are more chemical than pharmaceutic; hence in such cases discussion of manufacture will be left for Part III., and the fact so noted.

Lastly, these arrangements will obtain as far as possible in all the different classes of preparations discussed in Part II. Particularly will the "general recipe" idea be applied in the case of tinctures and fluidextracts, where scores of each class of preparations are made by a process identical, save in choice of menstruum and fineness of powder.

AQUÆ AROMATICÆ—Aromatic Waters

Under this heading, the pharmacopœia gives a general process, directing the use of 2 mils of volatile oil, 15 Gm. of purified talc and recently boiled distilled water enough to make 1 liter. Permission is given to use the several alternative processes outlined on the preceding page.

Remarks.—The above statement gives pharmacopœial sanction to the manufacture of aromatic waters by the several processes there enumerated.

AQUA AMMONIÆ and AQUA AMMONIÆ FORTIOR

Both are solutions of the chemical, ammonia, and will be described on p. 450.

AQUA AMYGDALE AMARÆ—Bitter Almond Water

(Aq. Amygd. Amar.)

Condensed Recipe.

Ingredients.—Oil of bitter almond, 1 mil; recently boiled distilled water, 999 mils.

Manipulation.—Prepared by simple solution and filtration.

Remarks.—Note that the strength of this water is 0.1 of 1 per cent. and that it is not the same as the international bitter almond water, which is directed to contain 0.1 of 1 per cent. of hydrocyanic acid.

Dose.—4 mils (1 fluidrachm).

AQUA ANISI—Anise Water

(Aq. Anisi)

Condensed Recipe.

Ingredients.—Oil of anise, 2 mils; purified talc, 15 Gm.; recently boiled distilled water, enough to make 1000 mils.

Manipulation.—Triturate the oil with the purified talc, then with the water and finally filter. For details, see U.S.P., p. 55.

Remarks.—It is frequently stated that the percentage of oil in anise water is 0.2 of 1 per cent. This, however, is incorrect, inasmuch as scarcely more than half of the oil is dissolved by the water, the rest remaining in the talcum left on the filter.

Dose.—15 mils (4 fluidrachms).

AQUA AURANTII FLORUM—Orange Flower Water

(Aq. Aur. Flor.)

Condensed Recipe.—Dilute stronger orange flower water with an equal volume of water.

Remarks.—This water is made by the process of dilution. A radical change was made in both "rose water" and "orange flower water" in the revision of 1890.

What were known by these titles in the former pharmacopœias—the so-called triple distilled imported waters—are now official as the "stronger waters," while the terms rose water and orange flower water are applied to waters diluted to 50 per cent. by the addition of distilled water.

An ancient synonym for orange flower water which is sometimes employed in prescription writing is *aqua naphæ.*

AQUA AURANTII FLORUM FORTIOR—Stronger Orange Flower Water

(Aq. Aurant. Flor. Fort.)

The saturated aqueous distillate prepared by distilling the fresh flowers of *Citrus Aurantium amara* Linné (Fam. *Rutaceæ*) with water. Preserve it in bottles stoppered with a pledget of purified cotton and in a dark, cool place.

Source.—The commercial article.

Description.—Colorless and only faintly opalescent with pleasant orange flower odor and taste.

Impurities.—Metals. Test with hydrogen sulphide or sodium sulphide. For details see U.S.P., p. 55.

Manufacture.—No recipe is given by the pharmacopœia, but this water is made by cohobation, as already described on p. 172, the commercial article being "triple distilled."

Remarks.—The metallic impurity test given above is intended to prevent use of a water that has been kept too long in the copper containers (usually tin lined) in which the commercial article is usually shipped.

Medical Properties.—Flavor and mild sedative.

AQUA CAMPHORÆ—Camphor Water

Recipe.—Like anise water, except that in making 1000 mils the talc is triturated with a solution of 8 Gm. of Camphor in 8 mils. of alcohol

Remarks.—Camphor water is the only official water made by trituration with talc in which the base is not a volatile oil. In making it the camphor is dissolved in alcohol and the alcoholic solution is triturated with purified talc, as if it were a volatile oil.

Dose.—10 mils (2½ fluidrachms).

AQUA CHLORI (U.S.P. 1890)—Chlorine Water

The process of manufacture of this will be found on p. 373, as this is not the proper time to consider the chemical action. Chlorine water is a preparation which should be made freshly each time it is dispensed, and at present, the National Formulary provides a simple extemporaneous process for preparing a similar preparation, *liquor chlori compositus.*

AQUA CHLOROFORMI—Chloroform Water

(Aq. Chlorof.)

Condensed Recipe.—Chloroform and recently boiled distilled water, of each a sufficient quantity, are mixed together in a dark amber-colored bottle; enough chloroform being used to insure a slight excess after a saturated aqueous solution is obtained. For details, see U.S.P., p. 56.

Remarks.—The above recipe is a modification of the process of simple solution, the finished product being kept over a layer of chloroform. This is done in order that the finished product remain a saturated solution, experience proving that a filtered chloroform water soon loses all its volatile active principle, leaving nothing but ordinary water. The saturated solution contains about $\frac{1}{2}$ of 1 per cent. of chloroform.

Dose.—15 mils (4 fluidrachms).

AQUA CINNAMOMI—Cinnamon Water

Recipe.—1000 mils water is made exactly as is anise water, except that 2 mils oil of cinnamon is employed instead of the oil of anise.

Remarks.—Cinnamon water belongs to the same class as anise water, made by the same method, and the remarks applied to the strength of anise water are equally forcible in the case of the water under consideration. It must be borne in mind that the oil of cinnamon from which the water is made is very irritating, and often in the dilution found in cinnamon water the taste is decidedly biting. For this reason the pharmacopœia directs, when making chalk mixture, that the cinnamon water be used diluted with a quantity of water, as explained on p. 257.

Dose.—15 mils (4 fluidrachms).

AQUA CREOSOTI—Creosote Water

Recipe.—Made like bitter almond water, by simple solution, except that 10 mils of creosote are mixed with 990 mils of boiled distilled water.

Remarks.—Creosote water is not a permanent preparation, for the filtered solution, on standing, becomes turbid, and deposits some of the decomposition products of the creosote in the form of a smeary tar.

For this reason the pharmacopœia directs it to be freshly prepared.

Dose.—10 mils (2$\frac{1}{2}$ fluidrachms).

AQUA DESTILLATA—Distilled Water
and
AQUA DESTILLATA STERILIZATA—Sterilized Distilled Water

These officials being chemicals rather than pharmaceuticals, will be discussed in Part III.

AQUA FŒNICULI—Fennel Water

Recipe.—Made by triturating 2 mils Oil of Fennel with purified talc and water to make 1000 mils. Details identical with recipe for anise water.

Dose.—15 mils (4 fluidrachms).

AQUA HAMAMELIDIS—Hamamelis Water

(Aq. Hamam Witch Hazel Water. Distilled Extract of Witch Hazel)

A saturated aqueous liquid obtained by distilling with steam or water the bark, twigs, smaller stems or the entire shrub of *Hamamelis virginiana* Linné (Fam. *Hamamelidaceæ*) collected in the autumn and adding *one hundred and fifty mils* of alcohol to each *eight hundred and fifty mils* of distillate. Preserve it in tightly closed containers in a cool place.

Source.—The commercial article containing not less than 14 per cent. of absolute grain alcohol.

Description.—Colorless or faint yellow liquid of characteristic odor. Sp. gr., 0.979 to 0.982.

Impurities.—Metals, formaldehyde, methyl alcohol. For details see U.S.P., p. 59.

Remarks.—This official is what is commonly called *distilled extract of witch hazel*, and has attained widespread popularity through the persistent advertising of one of its proprietary forms. Its therapeutic value is doubtful, many authorities claiming that its sole virtue resides in the alcohol it contains. Of particular importance to the retailer is the pharmacopœial demand that this product contain 14 per cent. *grain* alcohol (ethyl alcohol of the pharmacopœia), and that no formaldehyde be present. Many distillers have of late used wood alcohol, and in the crusade against the use of this poison in drugs several honest pharmacists have been prosecuted for dispensing methylated witch hazel—another illustration of the importance of the testing, by the pharmacist, of every product sold by him under his label and not made in his laboratory.

Dose.—8 mils (2 fluidrachms).

AQUA MENTHÆ PIPERITÆ—Peppermint Water

Recipe.—1000 mils is made from 2 mils Oil of Peppermint by process, exactly the same as that for making anise water—trituration with purified talc.

Dose.—15 mils (4 fluidrachms).

AQUA MENTHÆ VIRIDIS—Spearmint Water

Recipe.—1000 mils is made from 2 mils Oil of Spearmint, exactly as in the recipe for anise water.

Dose.—15 mils (4 fluidrachms).

AQUA ROSÆ—Rose Water

Recipe.—By dilution of stronger Rose Water with equal quantity of water, as in recipe for orange flower water.

AQUA ROSÆ FORTIOR—Stronger Rose Water

(Aq. Ros. Fort.)

The saturated aqueous distillate prepared by distilling the fresh flowers of *Rosa centifolia* Linné (Fam. *Rosaceæ*) with water. Preserve it in bottles stoppered with a pledget of purified cotton, in a cool, dark place.

Source.—The commercial article.

Description.—Clear and colorless liquid, smelling like roses.

Impurities.—Metals. Test with hydrogen sulphide or sodium sulphide. For details, see U.S.P., p. 60.

Manufacture.—No recipe given by the pharmacopœia, but it is a triple distilled water.

Remarks.—The two varieties of rose water are analogous to the two official orange flower waters already discussed.

Aqua Phenolata N.F. is made by dissolving 22 mils of liquefied phenol in 978 mils of distilled water.

Medical Properties of Waters.—The medical properties of most pharmaceutic preparations are those of the drugs from which they are obtained, and therapeutic consideration will be found in the proper place under the drug which is the leading ingredient.

In some few cases, however, the preparation consists of a blending of ingredients giving different action than the constituent drugs; or possibly may be a commercial, ready-made article, the constituents of which are not official. In such cases, illustrated in this chapter in orange flower water, the medical properties will be discussed at the time the preparation is considered.

Waters as a class are usually such diluted preparations that they are scarcely used as medicines, but are generally employed as vehicles. As notable exceptions, however, must be cited such waters as the ammonia waters and chlorine water; these, being rather powerful preparations and having special uses, will be considered in their place among the chemicals.

DOSES OF OFFICIAL WATERS

1 mil (15 minims)	Ammonia water.
4 mils (1 fluidrachm)	Bitter almond water.
10 mils (2½ fluidrachms)	Camphor water, creosote water.
15 mils (4 fluidrachms)	Anise water, chloroform water, cinnamon water, fennel water, peppermint water, spearmint water.
No dose given	Hamamelis water, the orange flower water, the rose waters.

Stronger ammonia water should never be dispensed for administration by a patient, it being recognized by the pharmacopœia merely as a standard form of ammonia which can be diluted to a 10 per cent. strength when required.

SPIRITS

A spirit is *an alcoholic solution of a volatile substance*, and, therefore, they differ from waters only in the solvent employed. For this reason a number of spirits are made from substances which are also used in the manufacture of waters. Practically, all the volatile oils represented in the list of aromatic waters are found in alcoholic solutions among the spirits. The number of spirits, however, is larger than that of the waters, due to the superior solubility of oils in alcohol. Moreover, the amount of oils found in spirits is much greater than that found in waters, most of the spirits containing from 5 to 10 per cent. or even 20 per cent. of the oil.

TABLE OF OFFICIAL SPIRITS

Manufacture.	*Galenic Preparations.*	*Chemical Preparation.*
Simple solution or dilution.	Spirit of ammonia, aromatic.	Spirit of nitrous ether.
	Spirit of anise.	
	Spirit of bitter almond.	
	Spirit of camphor.	
	Spirit of chloroform.	
	Spirit of cinnamon.	
	Spirit of ether.	
	Spirit of ether, compound (U.S.P., viii).	
	Spirit of gaultheria (U.S.P., viii).	
	Spirit of glyceryl trinitrate.	
	Spirit of juniper.	
	Spirit of juniper, compound.	
	Spirit of lavender.	
	Spirit of orange, compound.	
Gaseous solution	Spirit of ammonia. (U.S.P. viii).	
Solution with maceration	Spirit of peppermint.	
	Spirit of spearmint.	
Distillation	Whisky. (U.S.P. viii).	
	Brandy. (U.S.P. viii).	

As is seen in the above chart, the official spirits are made in two different ways:

Simple Solution or Dilution.—This process is simply adding and dissolving the medicated substance in alcohol. (In this group we find twelve of the fourteen official spirits.) A general formula for a *spirit of a volatile oil* is given in the National Formulary.

Solution by Maceration.—Two official spirits are made in this way—peppermint and spearmint. In each case the flavoring constituent is a volatile oil, but in deference to the wishes of the public who desire a spirit colored like the drug from which it is made, the pharmacopœia directs that, after the oil is added to the alcohol, it is to be macerated with some of the drug until the color of the latter has been absorbed by the alcohol.

In the eighth edition of the pharmacopœia, one spirit—spirit of ammonia—was made by *gaseous solution;* while two—whisky and brandy—are prepared by distillation. Neither of these products are recognized in the present pharmacopœia.

Two official spirits may be considered as made by *chemical action*—spirit of glyceryl trinitrate and spirit of nitrous ether. In one case, however, no direction is given by the pharmacopœia for the preparation of the chemical (glyceryl trinitrate), it being a task considered too dangerous for the ordinary drug-store; while in the case of the spirit of nitrous ether, the spirit is really made by dissolving the finished ethyl nitrite in alcohol, and the process may, therefore, be considered as a case of simple solution or dilution. For this reason both of these preparations are found in the chart given above under the head of simple solution or dilution.

SPECIAL NOTES ON OFFICIAL SPIRITS

SPIRITUS ÆTHERIS—Spirit of Ether

(Sp. Æth.—Hoffmann's Drops)

Condensed Recipe.—Dissolve 325 mils of ether in alcohol enough to make 1000 mils.

Remarks.—This is made by the simple solution of ether and alcohol, and is sold in Germany under the name of Hoffmann's drops.

Dose.—4 mils (1 fluidrachm).

SPIRITUS ÆTHERIS NITROSI—Spirit of Nitrous Ether

A full explanation of this important preparation, commonly called *sweet spirits of nitre*, will be found on p. 596.

SPIRITUS AMMONIÆ AROMATICUS—Aromatic Spirit of Ammonia

This important pharmaceutical can best be considered under the Ammonia Compounds (p. 454).

SPIRITUS AMYGDALÆ AMARÆ—Spirit of Bitter Almond

(Sp. Amygd. Amar.)

Condensed Recipe.—Dissolve 10 mils of oil of bitter almond in 800 mils of alcohol and add enough distilled water to make 1000 mils.

Remarks.—This preparation as stated above is not to be sold as "essence of bitter almond" since it is made from an oil containing hydrocyanic acid (p. 704); hence it is not safe to use indiscriminately. Essences or flavoring extracts should, of course, be harmless alcoholic preparations of aromatic principles and in making a flavoring essence of almond, an oil that has been freed from hydrocyanic acid should be employed. Among the harmless "essences" might be cited spirit of peppermint, spirit of spearmint and also spirit of lemon, U.S.P., 1890. Essence of ginger and essence of vanilla are respectively tincture of ginger and tincture of vanilla. The spirit of bitter almond, it might be worth noting, contains about 20 per cent. of water.

Dose.—0.5 mil (8 minims).

SPIRITUS ANISI—Spirit of Anise

Recipe.—100 mils Oil of Anise dissolved in 900 mils Alcohol. Details like recipe for spirit of ether.

Remarks.—This is a 10 per cent. preparation made by simple solution. Bear in mind that the alcohol of the present pharmacopœia is equivalent to the deodorized alcohol (Cologne Spirits) of the pharmacopœia of 1890, and is devoid of the unpleasant odor which ordinary alcohol leaves on evaporation. In the preparation of essences made from fine oils this grade of alcohol must be used instead of ordinary alcohol.

Dose.—2 mils (30 minims).

SPIRITUS AURANTII COMPOSITUS—Compound Spirit of Orange

(Sp. Aur. Co.)

Condensed Recipe.

Ingredients.—Oil of orange, 200 mils; oil of lemon, 50 mils; oil of coriander, 20 mils; oil of anise, 5 mils; alcohol, enough to make 1 liter.

Manipulation.—Mix the oils with the alcohol. For details, see U.S.P., p. 406.

Remarks.—This preparation, used as the flavor in *aromatic elixir* (p. 205), must be made of the best oils and alcohol if it is to be satisfactory. The official provision as to storing in well-filled bottles in a cool, dark place is to prevent the oils from growing terebinthinate.

SPIRITUS CAMPHORÆ—Spirit of Camphor

(Sp. Camph.)

Condensed Recipe.—Dissolve 100 gm. camphor in 800 mils of alcohol and filter, washing filter with enough alcohol to make 1 liter.

Impurity.—Added water. Anhydrous potassium carbonate not liquefied when immersed in the spirit. See U.S.P.

Assay.—Polariscopic. For details, see U.S.P., p. 406 and Part V. of this book.

Remarks.—Note that the recipe of the pharmacopœia does not direct the addition of water, and provides a test for the presence of water as well as polariscopic assay for the spirit (Part V). The addition of water is therefore considered by pure food officials as an adulteration.

Dose.—1 mil (15 minims).

SPIRITUS CHLOROFORMI—Spirit of Chloroform

Recipe.—Made by dissolving 60 mils Chloroform in 940 mils Alcohol. Details similar to the recipe for spirit of ether.

Dose.—2 mils (30 minims).

SPIRITUS CINNAMONI—Spirit of Cinnamon

Recipe.—Made by dissolving 100 mils Oil of Cinnamon in 900 mils Alcohol, as in making spirit of ether.

Dose.—2 mils (20 minims).

SPIRITUS GLYCERYLIS NITRATIS—Spirit of Glyceryl Trinitrate

This very important official, Spirit of Nitroglycerin, is fully described on p. 611. Here mention must be made, however, of the pharmacopœial warning, that even tasting a small quantity of it is liable to produce violent headache; also mention must be made that, since it contains the very explosive nitroglycerin, great care must be taken to prevent the spilling of the spirit. When the alcohol has evaporated, nitroglycerin remains, and may be brought to an explosion by simple concussion. If the spirit is spilled on the floor or elsewhere, it should be immediately treated with a diluted solution of soda, which will break it up into the two harmless substances—glycerin and sodium nitrate—and these can then be washed up.

SPIRITUS JUNIPERI—Spirit of Juniper

Recipe.—Oil of Juniper, 50 mils; Alcohol, 950 mils, dissolved as in making spirit of ether.

Dose.—2 mils (30 minims).

SPIRITUS JUNIPERI COMPOSITUS—Compound Spirit of Juniper

(Sp. Junip. Co.)

Condensed Recipe.

Ingredients.—Oil of Juniper, 8 mils, oil of caraway, 1 mil; oil of fennel, 1 mil; alcohol. 1400 mils; water enough to make 2000 mils.

Manipulations.—Dissolve the oils in the alcohol and then add the water.

Remarks.—The preparation is intended as a substitute for gin, which is made by distilling fermented rye and malt, macerating the distillate with juniper berries, and redistilling.
Dose.—10 mils (2½ fluidrachms).

SPIRITUS LAVANDULÆ—Spirit of Lavender

Recipe.—Oil of Lavender Flowers, 50 mils; Alcohol, 950 mils, dissolved as in making spirit of ether.

Dose.—2 mils (30 minims).

SPIRITUS MENTHÆ PIPERITÆ—Spirit of Peppermint

(Sp. Menth. Pip—Essence of Peppermint)

Condensed Recipe.—
Ingredients.—Oil of peppermint, 100 mils; peppermint, 10 Gm.; alcohol enough to make 1 liter.
Manipulation.—Macerate the peppermint leaves with water during one hour and then strongly express them. Dissolve the oil in alcohol, add the peppermint leaves and macerate six hours. After filtration run through the filter enough alcohol to make 1 liter. For details, see U.S.P., p. 409.

Remarks.—This is a 10 per cent. preparation of the oil of peppermint made with alcohol, and macerated with sufficient peppermint leaves to give it a green color. This is the popular *essence of peppermint.*
Dose.—2 mils (30 minims).

SPIRITUS MENTHÆ VIRIDIS.—Spirit of Spearmint.

Recipe.—Oil of Spearmint, 100 mils; Spearmint (bruised), 10 Gm.; Alcohol, to make 1000 mils. Make exactly as in recipe for spirit of peppermint.

Dose.—2 mils (30 minims).

Spiritus Ætheris Compositus (U.S.P. viii: N.F. iv) is prepared by mixing 325 mils of ether, 650 mils of alcohol and 25 mils of ethereal oil. It is usually called *Hoffman's Anodyne* and because of the presence of the expensive ethereal oil (p. 597) is liable to be adulterated. It should therefore be prepared by the pharmacist from an ethereal oil of known reliability. *Dose* 4 mils (1 fluidrachm).

Spiritus Ammoniæ (U.S.P. viii) is made by gaseous solution and like ammonia water contains 10 per cent. of ammonia gas (p. 451).

Spiritus Gaultheriæ (U.S.P. viii) is made by dissolving 50 mils of oil of gaultheria in 950 mils of alcohol. Commercial *essence of wintergreen* is usually made from the synthetic methyl salicylate (p. 711).

Spiritus Limonis (U.S.P., 1890) is now replaced by the official *tincture of lemon peel* (p. 229). The spirit (*essence of lemon*) is prepared by dissolving 50 mils of oil of lemon in 950 mils of alcohol and then macerating in the mixture 50 Gm. of grated lemon peel, which gives the product a yellow color. The oil used should be free from terebinthinate odor and the alcohol should be strictly pharmacopœial.

Spiritus Phosphori (U.S.P., 1890) is a 1 per cent. solution of phosphorus, made with absolute alcohol by the process of upright condensation. (See p. 101.) This process was employed to save undue evaporation of alcohol, it being necessary to digest the phosphorus in boiling alcohol for several hours in order to dissolve it. When this process is carried on in an ordinary flask, a large amount of alcohol would be lost by evaporation, but if the upright condenser is inserted in the neck of the flask, the vapor of alcohol passing through the cold condensing tube is converted into liquid, and drops back into the flask from which it has just emerged. Spirit of phosphorus was official because an ingredient of the *elixir of phosphorus* of the pharmacopœia of 1890.

THE SPIRITS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Spiritus ætheris compositus.	....	....	See p. 182.
Spiritus acidi formici.	Spiritus formicarum; spirit of ants.	Formic acid, 40 mils; distilled water, alcohol.	*Dose.*—4 mils (1 fluidrachm).
Spiritus ammoniæ anisatus.	Liquor ammoniæ anisatus.	Anethol, 30 mils; ammonia water; alcohol	*Dose.*—1 mil (15 minims).
Spiritus cardamomi compositus.	Compound spirit of cardamom.	Oils of cardamom, sweet orange, cinnamon, clove and caraway; anethol; alcohol.	Flavoring used in making elixirs.
Spiritus myrciæ compositus.	Compound spirit of myrcia.	Oils of myrcia, sweet orange and pimenta; alcohol; water.	A well-perfumed form of *bay rum*.
Spiritus odoratus.	Perfumed spirit.	Oils of bergamot, lemon, rosemary, lavender and orange flowers; acetic ether; water; alcohol.	An agreeable form of *cologne water*.
Spiritus sinapis.	Spirit of mustard.	Volatile oil of mustard, 2 mils; alcohol.	
Spiritus vanillini compositus.	Compound spirit of vanillin.	Vanillin; oils of sweet orange, cardamom and cinnamon; alcohol.	Used in flavoring elixirs.

DOSES OF SPIRITS

0.05 mils (1 minim)............	Spirit of glyceryl trinitrate.
0.5 mil (8 minims..............	Spirit of bitter almond.
1.0 mils (15 minims)...........	Spirit of camphor.
2 0 mils (30 minims)...........	Spirits of nitrous ether, ammonia aromatic, anise, chloroform, cinnamon, juniper, lavender, peppermint, and spearmint.
4 mils (1 fluidrachm)...........	Spirits of ether.
10 mils (2½ fluidrachms)........	Spirit of juniper compound.

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CHAPTER XII

SOLUTIONS, MUCILAGES, SYRUPS, AND HONEYS

SOLUTIONS

SOLUTIONS constitute that class of pharmaceuticals defined as "*aqueous solutions of non-volatile bodies.*" This definition is redundant, inasmuch as we say that a "solution" (the class of pharmaceuticals) is a "solution" (that is, a product of the physical phenomenon called solution, which has been discussed on p. 118). In other words, the student at the outset should get a clear idea of the three meanings of the word "solution." First, the physical phenomenon of molecular subdivision resulting in a homogeneous fluid; second, the physical group of solutions, those homogeneous fluids produced by molecular subdivision, and including such pharmaceuticals as waters, spirits, glycerites, tinctures, etc; and, third, the narrow pharmaceutic "solution," which includes only that class of physical solutions which have water as the solvent and a non-volatile body as dissolved substance.

A pharmacopœial solution is an aqueous preparation, free from sugar (exception, Solution of Magnesium Citrate), made by the ordinary process of solution. Some writers divide this class into simple and chemical solutions, while others oppose such a distinction, claiming there is no real difference in the liquefaction occurring in, say, solution of arsenous acid and in solution of ferric acetate. The latter class of writers claim that the chemical combination occurring in the formation of a so-called "chemical solution" has nothing to do with the act of solution, the chemical reaction first occurring, then being followed by the solution of the newly formed substance or of the ions of which it is composed. (See p. 119.) There is much truth in the argument that the arsenous acid in the first solution cited above is produced by chemical reaction, as much as is the ferric acetate in the other preparation; that the fact whether the substance is dissolved at the moment of formation or after some time has elapsed makes little difference.

In this book we will divide solutions into galenic preparations (simple solutions) and into chemical preparations (chemical solutions), for the same reason that we group all pharmaceuticals into the two classes; that in Part II. we will discuss only these preparations made without chemical action, leaving those in which a chemical action occurs for consideration in Part III.

The manufacture of solutions is simple or complex, according as the preparation is a galenic or a chemical. Galenic solutions are prepared by simply dissolving the substance in an appropriate quantity of water in either a flask or a bottle, and dissolving by agitation, or by first reducing the substance to a fine powder by trituration in a mortar, and gradually adding water to the substance in the mortar.

The preparation of the so-called "simple solutions" is an easy matter —so easy that the average druggist is grossly careless with them. They should be elegant preparations; hence the careful pharmacist is generous with his filter-paper, having all his solutions (save possibly lead water) as clear as crystal. This applies to all solutions, and especially to extemporaneous prescriptions. Have all preparations, intended to be clear, fairly sparkling, for the only method possessed by the public of judging

the skill of the pharmacist is the appearance of his preparations and the neatness of his packages.

The chemical solution, on the other hand, usually requires a high degree of skill in its manufacture, and the description of this class had best be left until we consider the substance from the chemical aspect in Part III. The following table gives a list of officials arranged as galenic or chemical:

TABLE OF OFFICIAL SOLUTIONS

Manufacture.	*Galenic Preparations.*	*Chemical Preparations.*
These galenics are made by simple solution.	Solution of arsenous acid.	Solution of ammonium acetate.
	Solution of arsenous and mercuric iodide.	Solution of calcium hydroxide.
	Solution of formaldehyde.	Solution of creosol, compound.
	Solution of iodine, compound.	Solution of ferric chloride.
	Solution of lead subacetate, diluted.	Solution of ferric subsulphate.
	Solution of potassium hydroxide.	Solution of ferric sulphate.
	Solution of sodium arsenate.	Solution of hydrogen dioxide.
	Solution of sodium hydroxide.	Solution of iron and ammonium acetate.
This galenic is made by simple solution and sterilization.	Physiological solution of sodium chloride.	Solution of lead subacetate.
This galenic is made by decoction and sterilization.	Solution of hypophysis.	Solution of magnesium citrate.
		Solution of potassium arsenite.
		Solution of potassium citrate.
		Solution of chlorinated soda.
		Solution of sodium glycerophosphate.
		Solution of zinc chloride.

SPECIAL NOTES ON OFFICIAL SOLUTIONS

LIQUOR ACIDI ARSENOSI—Solution of Arsenous Acid

(**Liq. Acid. Arsen.**—Hydrochloric Solution of Arsenic. "Solution of Arsenic Chloride")

An aqueous solution, containing arsenous acid equivalent to not less than 0.975 per cent. nor more than 1.025 per cent. of As_2O_3 (197.92).

Condensed Recipe.

Ingredients.—Arsenic trioxide, 10 Gm.; diluted hydrochloric acid, 50 Gm.; distilled water, enough to make 1 liter.

Manipulation.—Dissolve the acid in 250 Gm. water; boil the arsenic trioxide therein until it is dissolved. After cooling, add enough water to make 1 liter.

Remarks.—This is a 1 per cent. solution of arsenous acid in water, containing 5 per cent. of diluted hydrochloric acid. The preparation was formerly called *solution of arsenic chloride*, it being supposed that the hydrochloric acid combined with the arsenous acid with the formation of the chloride. This view is not generally held, however, at the present time, the function of the hydrochloric acid being supposed as merely rendering the arsenous acid more soluble.

Dose.—0.2 mil (3 minims).

LIQUOR AMMONII ACETATIS—Solution of Ammonium Acetate

This useful preparation, known as *Spirit of Mindererus*, will be discussed on p. 452.

LIQUOR ARSENI ET HYDRARGYRI IODIDI—Solution of Arsenous and Mercuric Iodide

(Liq. Arsen. et Hydrarg. Iod.—Donovan's Solution)

An aqueous solution containing not less than 0.95 per cent. nor more than 1.05 per cent. of AsI_3 (455.72) and not less than 0.95 per cent. nor more than 1.05 per cent. of HgI_2 (454.44).

Condensed Recipe.

Ingredients.—Arsenous and mercuric iodides, of each 10 Gm.; distilled water, enough to make 1 liter.

Manipulation.—Triturate the iodides with 150 mils of water until they are dissolved. Filter and wash filter with enough water to make 1 liter. For details, see U.S.P., p. 238.

Remarks.—This preparation has as its synonym *Donovan's Solution*, and contains 1 per cent. of arsenous iodide and 1 per cent. of mercuric iodide dissolved in water. The pharmacopœia directs that Donovan's solution should be not more than a pale yellow color; but on standing this solution becomes red, and such red solutions should not be dispensed, as it is supposed to contain traces of free iodine. This may be prevented by placing a globule of mercury in the container holding the solution and by following the pharmacopœial direction to store in well-filled amber bottles.

LIQUOR CALCIS—Solution of Calcium Hydroxide

This well-known preparation, commonly called *Lime Water*, will be considered among the other preparations of calcium (p. 468). In the present system of grouping pharmaceuticals the old Latin name *Aqua Calcis* is a misnomer, since its active constituent, calcium hydroxide, is a non-volatile solid, while official waters are solutions of volatile bodies.

LIQUOR CRESOLIS COMPOSITUS—Compound Solution of Cresol

This new official, similar to but not identical with the patent preparations, *creolin* and *lysol*, will be discussed among the cresol derivatives (p. 701).

LIQUOR FERRI CHLORIDI—Solution of Ferric Chloride

LIQUOR FERRI ET AMMONII ACETATIS—Solution of Iron and Ammonium Acetate

LIQUOR FERRI SUBSULPHATIS—Solution of Ferric Subsulphate

LIQUOR FERRI SULPHATIS—Solution of Ferric Sulphate

These four chemical solutions of iron will be discussed in the chapter devoted to that element (Chapter XXXI).

LIQUOR FORMALDEHYDI—Solution of Formaldehyde

This 37 per cent. solution of the gas formaldehyde, sometimes called *Formalin*, will be discussed under Formaldehyde (p. 585).

LIQUOR HYDROGENII DIOXIDI—Solution of Hydrogen Dioxide

This largely used 3 per cent. solution of hydrogen dioxide is discussed at length on p. 370.

LIQUOR HYPOPHYSIS—Solution of Hypophysis

This new official solution will be discussed under the animal products in Chapter LI.

LIQUOR IODI COMPOSITUS—Compound Solution of Iodine

(Liq. Iodi Co.—Lugol's Solution)

An aqueous solution containing not less than 4.8 per cent. nor more than 5.2 per cent. of I and not less than 9.8 per cent. nor more than 10.2 per cent. of KI. Preserve the solution in glass-stoppered bottles, protected from light.

Condensed Recipe.

Dissolve 5 Gm. iodine and 10 Gm. potassium iodide in enough distilled water to make 100 mils.

Description.—Transparent brown liquid.

Test for Identity.—Blues starch paste. For details see U.S.P., p. 248, and Part V of this book.

Assay.—See U.S.P. and Part V of this book.

Remarks.—The synonym of this compound is *Lugol's solution,* which should not be confounded with *Dobell's solution* (p. 191), as it was in one case when a pharmacist translated the poor writing of a physician calling for Dobell's solution into Lugol's solution, which was accordingly sprayed into the throat, with exceedingly irritating results.

Compound solution of iodine contains 5 per cent. of iodine dissolved in water by means of 10 per cent. of potassium iodide. This proves the interesting fact that while iodine scarcely dissolves in water, it is freely soluble in solution of potassium iodide.

Dose.—0.2 mil (3 minims).

LIQUOR MAGNESII CITRATIS—Solution of Magnesium Citrate

This popular and valuable official, sometimes called "Purgative Lemonade," will be discussed on p. 463.

LIQUOR PLUMBI SUBACETATIS—Solution of Lead Subacetate

Discussed on p. 547.

LIQUOR PLUMBI SUBACETATIS DILUTUS—Diluted Solution of Lead Subacetate

(Liq. Plumb. Subacet. Dil.—Lead Water)

Condensed Recipe.

Mix 40 Gm. solution of lead subacetate with enough previously boiled distilled water to make 1 liter.

Remarks.—This official is called *lead water,* and contains but 4 parts of solution of lead subacetate to 100 parts finished solution; hence it is much weaker. The pharmacopœia provides that the solution of lead subacetate be diluted with distilled water which has been previously boiled and cooled. The boiling in this case is to rid the water of its dissolved carbonic acid, for if the unboiled water is brought into contact with the solution of lead subacetate, a precipitation of lead carbonate occurs, with corresponding loss in the lead strength of the official preparation. In order to prevent the formation of this lead carbonate in the official product the pharmacopœia directs that the solution be kept in well-filled tightly-stoppered bottles. Lead water is best dispensed opalescent, to avoid the danger of confusing this poisonous preparation with the harmless "lime water."

Medical Properties.—Used exclusively externally as a soothing wash in frost-bite, ivy-poisoning, etc. Hence no dose is given by the pharmacopœia.

LIQUOR POTASSII ARSENITIS—Solution of Potassium Arsenite

LIQUOR POTASSII CITRATIS—Solution of Potassium Citrate

LIQUOR POTASSII HYDROXIDI—Solution of Potassium Hydroxide

Can best be studied among the derivatives of potassium (Chapter XXV.).

LIQUOR SODÆ CHLORINATÆ—Solution of Chlorinated Soda

See p. 376.

LIQUOR SODII ARSENATIS—Solution of Sodium Arsenate

(**Liq. Sod. Arsen.**)

An aqueous solution containing not less than 0.975 per cent. nor more than 1.025 per cent. of Na_2HAsO_4 (185.97).

Condensed Recipe.

Dissolve 1 Gm. exsiccated sodium arsenate in enough water to make 100 mils.

Remarks.—This is a 1 per cent. solution of sodium arsenate in water. The sodium arsenate must, however, be previously deprived of its water of crystallization; that is, it must be the exsiccated sodium arsenate of the present pharmacopœia. This preparation is one of the four arsenical solutions directed by the pharmacopœia, the others being solution of arsenous acid, solution of arsenous and mercuric iodides, and solution of potassium arsenite, the latter being considered among the chemical solutions.

It is well to bear in mind the strength of these four arsenical solutions, noting that while all of them are 1 per cent., it does not mean that each contains 1 per cent. of arsenic trioxide, U.S.P. Two of these, solution of arsenous acid and solution of potassium arsenite, contain 1 per cent. of arsenic trioxide; solution of arsenic and mercuric iodide contains 1 per cent. of arsenic iodide, while in solution of sodium arsenate the arsenical compound is sodium arsenate.

Dose.—0.2 mil (3 minims).

LIQUOR SODII CHLORIDI PHYSIOLOGICUS—Physiological Solution of Sodium Chloride

(**Liq. Sod. Chlor. Physio.**—Physiological Salt Solution. Normal Salt Solution)

Condensed Recipe.

Dissolve 8.5 Gm. sodium chloride in distilled water enough to make 1 liter and then sterilize. For details, see U.S.P., p. 254.

Remarks.—This new official preparation is furnished in response to a demand for a *normal saline solution* (p. 435). Note that the product must be dispensed in sterile condition (p. 124) and must not be used when more than forty-eight hours old.

LIQUOR SODII GLYCEROPHOSPHATIS—Solution of Sodium Glycerophosphate.—This galenic can best be discussed under Sodium Glycerophosphate (p. 437).

LIQUOR SODII HYDROXIDI—Solution of Sodium Hydroxide

While this preparation, commonly called *solution of soda*, is directed by the present pharmacopœia to be made by simple solution of sodium hydroxide in water, former pharmacopœias directed its manufacture by chemical action. Since the chemistry of this solution is most interesting, discussion will be deferred until we can take up the chemical side (p. 427).

The same treatment applies with equal force to solution of potassium hydroxide.

LIQUOR ZINCI CHLORIDI—Solution of Zinc Chloride

See p. 482.

THE DOSES OF OFFICIAL SOLUTIONS

0.1 mil (1½ minims)	Solutions of arsenous and mercuric iodide and of ferric chloride.
0.2 mil (3 minims)	Solutions of arsenous acid, ferric subsulphate, iodine compound, potassium arsenite, and sodium arsenate.
0.35 mil (6 minims)	Solution of sodium glycerophosphate.
1 mil (15 minims)	Solutions of hypophysis, potassium hydroxide, and sodium hydroxide.
4 mils (1 fluidrachm)	Solution of hydrogen dioxide.
15 mils (4 fluidrachms)	Solutions of ammonium acetate, calcium hydroxide, iron and ammonium acetate, and potassium citrate.
350 mils (12 fluidounces)	Solution of magnesium citrate.

No doses are assigned the official solutions not mentioned in the above list.

Liquor Antisepticus (U.S.P. VIII) was a hydro-alcoholic solution of boric and benzoic acids combined with the more or less antiseptic aromatic substances, thymol, eucalyptol and oils of peppermint, gaultheria and thyme. *It is important to note that the antiseptic solution of the National Formulary differs considerably from the former U.S.P. recipe* (see below). These preparations are similar to the many antiseptic solutions exploited under trade names and if properly prepared they are highly agreeable products. For satisfactory results, however, it is essential that the volatile oils be of the finest quality.

THE SOLUTIONS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Liquor alumini acetatis.	Burow's solution.	Lead acetate; aluminum sulphate; water.	See p. 494.
Liquor alumini acetico-tartratis.	Solution of aluminum acetico-tartrate.	Alum; monohydrated sodium carbonate; glacial acetic acid; tartaric acid; water.	See p. 494.
Liquid alumini sub-acetatis	Solution of aluminum acetate.	Aluminum sulphate; acetic acid, precipitated calcium carbonate; water.	Largely used by German practitioners (p. 494.)
Liquor ammonii citratis.	Solution of ammonium citrate.	Citric acid; ammonia water; distilled water.	See p. 456.
Liquor antisepticus.	Antiseptic solution.	Boric acid, 25 Gm.; thymol; eucalyptol; methyl salicylate; oil of thyme; menthol; sodium salicylate, 1.2 Gm.; sodium benzoate, 6 Gm.; alcohol; water. Purified talc as clarifier.	See above. *Dose.*—4 mils (1 fluidrachm).
Liquor antisepticus alkalinus	Alkaline antiseptic solution.	Potassium bicarbonate, 32 Gm.; sodium benzoate, 8 Gm.; sodium borate, 32 Gm.; thymol, eucalyptol; oil of peppermint; methyl salicylate; alcohol; glycerin; water. Cudbear as color and magnesium carbonate as clarifier.	An agreeable product similar to the many proprietary products now on the market.

THE SOLUTIONS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Liquor arsenicalis Clemens.	Clemen's solution.	Arsenic trioxide, 10 gm; potassium bicarbonate; bromine; water.	Described on p. 527. *Dose.*—0.2 mil (3 minims).
Liquor auri et arseni bromidi.	Solution of gold and arsenic bromide.	Arsenic trioxide, 2.5 Gm.; bromauric acid, 3.25 Gm.; bromine water; distilled water.	*Dose.*—0.2 mil (3 minims).
Liquor bismuthi.	Solution of bismuth.	Glycerite of bismuth, 125 mils; alcohol; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Liquor bromi.	Smith's solution of bromine.	Bromine, 8.3 mils; potassium bromide, 12.5 Gm.; water.	Mix carefully to avoid irritating effect of bromine (p. 377).
Liquor calcis sulphuratæ.	'Vleminckx' solution.	Lime, 165 Gm.; sublimed sulphur, 250 Gm.; water.	See p. 381.
Liquor carmini.	Solution of carmine.	Carmine, 65 Gm.; ammonia water; glycerin; water.	Valuable coloring agent.
Liquor chlori compositus.	Compound solution of chlorine.	Potassium chlorate; hydrochloric acid; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Liquor coccineus.	Cochineal color.	Cochineal, 65 Gm.; potassium carbonate; alum; potassium bitartrate; glycerin; alcohol; water.	Another valuable coloring agent.
Liquor ferri acetatis.	Solution of ferric acetate.	Solution of ferric sulphate; glacial acetic acid; ammonia water; water.	*Dose.*—0.3 mils (5 minims).
Liquor ferri albuminati.	Solution of albuminate of iron.	Fresh egg albumin, 60 Gm.; solution of ferric oxychloride, 130 Gm.; sodium citrate; aromatic elixir; alcohol; distilled water.	*Dose.*—8 mils (2 fluidrachms).
Liquor ferri citratis.	Solution of ferric citrate.	Solution of ferric sulphate; citric acid; water. Ammonia water used as a precipitant.	*Dose.*—0.6 mil (10 minims).
Liquor ferri hypophosphitis.	Solution of ferric hypophosphite.	Ferric hypophosphite, 165 Gm.; potassium citrate, glycerin; water.	*Dose.*—1 mil (15 minims).
Liquor ferri nitratis.	Solution of ferric nitrate.	Solution of ferric sulphate; nitric acid; water. Ammonia water used as precipitant.	*Dose.*—0.3 mil (5 minims). See p. 517.
Liquor ferri oxychloridi.	Solution of ferric oxychloride.	Solution of ferric chloride, 300 mils; hydrochloric acid; glycerin; distilled water. Ammonia water used as precipitant.	*Dose.*—2 mils (30 minims).
Liquor ferri oxysulphatis.	Solution of ferric oxysulphate.	Ferrous sulphate, 165 Gm.; nitric acid (as oxidizer); distilled water.	This and the other inorganic iron preparations are discussed in Chapter XXXI.
Liquor ferri peptonati.	....	....	These two preparations as well as solution of albuminate of iron are discussed in Chapter LI.
Liquor ferri peptonati cum mangano.	....	....	
Liquor ferri protochloridi.	Solution of ferrous chloride.	Iron wire, 160 Gm.; hydrochloric acid, 625 Gm.; glycerin, diluted hypophosphorous acid; distilled water.	*Dose.*—0.6 mil (10 minims).
Liquor ferri salicylatis.	Solution of ferric salicylate.	Sodium salicylate, 125 Gm.; tincture of ferric citrochloride, 125 mils; ammonium carbonate; citric acid; methyl salicylate; glycerin; distilled water.	*Dose.*—8 mils (2 fluidrachms).
Liquor gutta-perchæ	Solution of gutta-percha.	Gutta-percha 15 Gm.; chloroform. Lead carbonate as clarifier.	Used like collodion as a protective for wounds.
Liquor hydrargyri et potassii iodidi.	Channing's solution.	Red mercuric iodide, 2.5 Gm.; potassium iodide, 2 Gm.; distilled water.	*Dose.*—0.2 mil (3 minims).
Liquor hydrargyri nitratis.	....	....	See p. 560.

THE SOLUTIONS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Liquor hydrastinæ compositus.	Colorless hydrastine solution.	Hydrastine hydrochloride, 3 Gm.; the chlorides of aluminum, calcium, magnesium and potassium; glycerin; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Liquor hypophosphitum.	Solution of hypophosphites.	The hypophosphites of calcium (35 Gm.) sodium (20 Gm.) and potassium (17.5 Gm.); hypophosphorous acid; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Liquor hypophosphitum compositus.	Compound solution of hypophosphites.	The hypophosphites of calcium (8.5 Gm.), potassium (8.5 Gm.), sodium (2.2 Gm.), iron (4.4 Gm.), manganese (2.2 Gm.) and quinine (2.2 Gm.); strychnine (0.065 Gm.; potassium citrate; hypophosphorous acid; orange flower water; glycerin; distilled water.	
Liquor iodi phenolatus.	Boulton's solution.	Compound solution of iodine, 15 mils; liquefied phenol, 6 mils; glycerin; water.	See p. 689.
Liquor magnesii sulphatis effervescens.	Effervescent solution of magnesium sulphate.	Magnesium sulphate, 25 Gm.; citric acid, syrup of citric acid, potassium bicarbonate; distilled water enough to make 350 mils.	A "charged" solution of magnesium sulphate. See p. 466.
Liquor pancreatini.	Solution of pancreatin.	Pancreatin, 17.5 Gm.; sodium bicarbonate, 50 Gm.; glycerin, compound spirit of cardamon; alcohol; sodium chloride; chloroform, 2 mils; distilled water. Magnesium carbonate as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Liquor pepsini.	Solution of pepsin.	Glycerite of pepsin, 50 mils; hydrochloric acid, 10 mils; glycerin; distilled water.	*Dose.*—8 mils (2 fluidrachms).
Liquor pepsini antisepticus.	Antiseptic solution of pepsin.	Pepsin; menthol; eucalyptol; methyl salicylate; alcohol; glycerin; diluted hydrochloric acid; distilled water. Purified talc as clarifier.	The uses of these three pepsin solutions are discussed in Chapter II.
Liquor pepsini aromaticus.	Aromatic solution of pepsin.	Pepsin, 17.5 Gm.; oils of cinnamon, pimenta and clove; hydrochloric acid; alcohol; glycerin; distilled water. Purified talc as a clarifier.	*Dose.*—8 mils (2 fluidrachms).
Liquor phosphatum acidus.	Solution of acid phosphate.	Precipitated calcium carbonate; magnesium carbonate; phosphoric acid; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Liquor phosphatum compositus.	Compound solution of phosphates.	Precipitated calcium carbonate; phosphates of iron and ammonium; bicarbonates of potassium and sodium; citric and phosphoric acids; glycerin; orange flower water; distilled water.	See p. 405.
Liquor phosphori.	Thompson's solution of phosphorus.	Phosphorus, 0.07 Gm.; dehydrated alcohol; spirit of peppermint; glycerin.	*Dose.*—0.6 mil (10 minims).
Liquor picis alkalinus.	Alkaline solution of tar.	Tar, 250 Gm.; potassium hydroxide 125 Gm.; water.	Used considerably by dermatologists.
Liquor picis carbonis.	Coal tar solution.	Coal tar 200 gm.; guillaja; alcohol.	Another dematological preparation.
Liquor potassii chlorinatæ.	Javelle water.	Potassium carbonate; chlorinated lime; water.	See p. 376.
Liquor sodæ et menthæ	Soda mint.	Sodium bicarbonate; aromatic spirit of ammonia; spearmint water.	*Dose.*—8 mils (2 fluidrachms).
Liquor sodii arsenatis, Pearson.	Pearson's solution.	Exsiccated sodium arsenate 0.1 Gm.; distilled water.	Only one-tenth the strength of the U. S. P. solution of sodium arsenate *Dose.*—2 mils (30 minims).
Liquor sodii boratis compositus.	Dobell's solution.	Sodium borate; sodium bicarbonate; liquefied phenol; glycerin; water.	Used as a nasal douche.

THE SOLUTIONS OF THE NATIONAL FORMULARY—*(Continued)*

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Liquor sodii citratis.	Potio Rivierii.	Citric acid; sodium bicarbonate; distilled water.	*Dose.*—8 mils (2 fluidrachms). See p. 418.
Liquor sodii citrotartratis effervescens.	Effervescent solution of sodium citro-tartrate.	Sodium bicarbonate, tartaric and citric acids; syrup of citric acid; distilled water.	Another effervescent purgative, dispensed in a strong bottle.
Liquor sodii phosphatis compositus.	. . . .	. . . .	See p. 440.
Liquor strychninæ acetatis.	Hall's solution of strychnine.	Strychnine, 0.178 Gm.; diluted acetic acid; alcohol; compound tincture of cardamom; distilled water.	*Dose.*—0.6 mil (10 minims).
Liquor zinci et alumini compositus.	Compound solution of zinc and aluminum.	Zinc sulphate; aluminum sulphate; betanaphthol; oil of thyme; water.	An antiseptic solution used for general purposes of disinfection.
Liquor zinci et ferri compositus.	Deodorant solution.	The sulphates of zinc, copper and iron; betanaphthol; oil of thyme; hypophosphorous acid; water.	An attractive blue-green solution used as a disinfectant.

COLLYRIA

These are special types of solutions recognized in some of the European pharmacopœias intended for use as eye washes. A typical illustration is *collyrium adstringens luteum* of the Austrian pharmacopœia, a translation of which is as follows:

Ammonia chloride,	0.50
Zinc sulpate,	1.25
Distilled water,	200.00
Camphor,	0.4
Diluted alcohol,	20.0
Saffron,	0.1

Digest twenty-four hours; then filter.

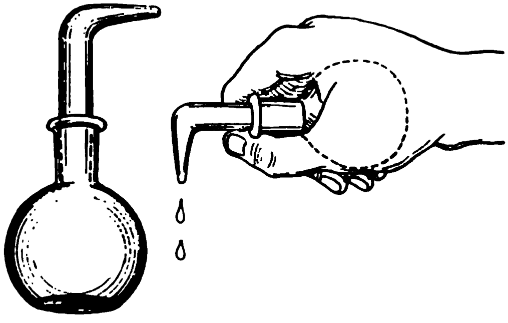

Fig. 174.—Dropping flask for collyria.

In dispensing collyria great care should be taken that the finished product is free from foreign particles. The filtration is best done through sterile absorbent cotton. A number of special bottles have been devised for dispensing collyria (Fig. 174).

MUCILAGES

The mucilages are *aqueous preparations containing viscid substances in solution or suspension*, and from a strictly physical point of view mucilages should scarcely be grouped among the solutions.

All mucilages should be freshly prepared, as their mucilaginous constituents when diluted with water are usually prone to fermentation.

One of the official mucilages is a jelly and the other is a liquid. One is prepared with hot water; the other with cold water. Both are galenic preparations.

SPECIAL NOTES ON OFFICIAL MUCILAGES

MUCILAGO ACACIÆ—Mucilage of Acacia
(Mucil. Acac.)

Condensed Recipe.

Dissolve 350 Gm. acacia (previously washed in cold water) in warm distilled water enough to make 1000 Gm., agitating the mixture in a tared bottle until solution is effected. For details, see U.S.P., p. 278.

Remarks.—This preparation contains 35 per cent. of washed gum arabic dissolved in water, and the pharmacopœia directs that the gum arabic be in the form of small pieces and not in a powder. For general prescription purposes, however, especially when the mucilage of gum arabic is directed as one of the several ingredients, the powdered gum arabic is generally used, its solution being much quicker than the gum arabic in lumps.

In preparing large quantities of the mucilage of acacia, as in making mucilage to sell as an adhesive, the solution of the gum can be facilitated by placing it in a muslin bag and suspending it on the surface of the water contained in the crock. In this way the gum arabic can be easily dissolved in the course of a few hours by means of a circulatory solution.

Dose.—15 mils (4 fluidrachms).

MUCILAGO TRAGACANTHÆ—Mucilage of Tragacanth
(Mucil. Trag.)

Condensed Recipe.

Ingredients.—Tragacanth, 6 Gm.; glycerin, 18 Gm.; water enough to make 100 Gm.

Manipulation.—Mix the glycerin with 75 mils of water, heat to boiling, add the tragacanth, macerate twenty-four hours. Then add the full amount of water and strain by expression. For details, see U.S.P., p. 278.

Remarks.—This contains 6 per cent. of tragacanth and 18 per cent. of glycerin, and is prepared by adding tragacanth to boiling water mixed with glycerin and straining after maceration for twenty-four hours. The glycerin aids in its preservation. It is a semi-solid of much value as a pill excipient, and is practically never used internally.

Mucilago ulmi U.S.P. VIII, was prepared by digesting 6 Gm. of elm bark in 100 mils of water for one hour, after which it was strained.

THE MUCILAGES OF THE NATIONAL FORMULARY

Latin name	English name	Ingredients (figures show amount used in 100 mils)	Remarks
Mucilago chondri.	Mucilage of fresh moss.	Chondrus, 3 Gm.; water, prepared by decoction.	Used in making emulsions.
Mucilago sassafras medullæ.	Mucilage of sassafras pith.	Sassafras, 2 Gm.; water. Prepared by cold infusion.	Practically the recipe of U.S.P. VIII. Used as the vehicle in eye lotions.

SYRUPS

The next class of preparations to claim our attention are the syrups, which are *preparations containing medicated or flavoring substances combined with a concentrated aqueous solution of sugar.*

A concentrated aqueous solution of sugar is called *syrup* or simple syrup. If the substance added to this is merely a pleasant fruit or an aromatic, the finished product is a *flavored syrup,* while if the addition is of a medicinal character, the product is a *medicated syrup.*

The manufacture of syrups, while it is simple in itself, is rather difficult to explain in a general way by reason of the many modifications in the individual processes which are directed in the pharmacopœia. Moreover, the manufacture of the syrups may be considered from two points of view: first, the method by which the sugar is dissolved, and second, the method in which the medicinal or flavoring constituent is blended with the sugar.

As far as dissolving the sugar is concerned, this is accomplished in several ways: first, the *solution of sugar with heat,* that is, by placing the sugar in an appropriate vessel, adding water, and possibly a medicated liquid, and warming the mixture until the sugar is dissolved. The second method is by dissolving the sugar in a medicated liquid without the use of heat—the so-called *cold process* of preparing syrups. This process must, in turn, be divided into two methods, the sugar being dissolved in the first case by *agitation* (by simply mixing the sugar with the medicated liquid, and shaking the container from time to time until the sugar is completely dissolved), and in the second case, by *percolation.* In this method a piece of sponge or large pledget of absorbent cotton is put in the neck of the percolator, the granulated sugar is poured thereon and packed down as well as circumstances permit, and the requisite amount of the liquid is poured in on the top. The liquid is attracted downward by the force of gravitation, and in traversing through the sugar dissolves enough of it to make a saturated solution; and in this way, if the requisite quantity of liquid is added, all the sugar will be dissolved, and at the end of the process nothing will remain in the percolator except the straining medium and any insoluble matter that was mixed with the sugar.

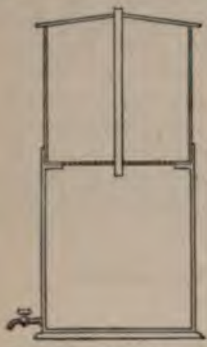
Fig. 175.—Syrup percolator.

For preparing pharmacopœial syrups this process of percolation is permitted, but the writer has found that it possesses the great objection that there is always a considerable quantity of sugar that is not dissolved by the percolating liquid, and in order to redissolve this it is necessary to spread the sugar carefully over the cotton plug and pass the liquid through once more. But even this is not always successful.

For the preparation of syrup for soda-fountain use this method of cold percolation is unexcelled, for in this case the complete solution of the sugar is not absolutely necessary. Soda syrup can be prepared in the very simple apparatus shown in Fig. 175. This apparatus was built of two five-gallon castor-oil tins, the lower one provided with a brass faucet, while a sufficient amount of the bottom of the upper one was left to form a margin on which rested a diaphragm of tin, pierced with holes, over which was placed a piece of Canton flannel which served as a strainer. Through the center of this diaphragm, up to the top of the upper can, passes a piece of tin tubing intended to permit the exit of air from the lower can. This diaphragm being placed in position, granulated sugar is thrown in the upper can until completely filled, and one gallon of water is poured thereon. The water penetrates the sugar, dissolving it, and is finally passed through the strainer on the diaphragm, dropping into the lower can a saturated solution of sugar and water. When the first gallon of water has passed through the sugar is repacked in the upper can, and a half-gallon of water poured on; and we thus obtain about four to five gallons of a thick, transparent syrup. The sugar remaining in the upper can is poured on paper, dried, and used another time with a fresh quantity of sugar. The quality of the sugar used in making syrups is of great importance, as some brands of sugar give syrup that does not keep well. "Crystal A" confectioners' sugar is the one recommended.

As to the special methods of manufacturing syrups, the following table gives a glance at the various processes employed.

TABLE OF OFFICIAL SYRUPS

Process	*Galenic Preparations.*	*Chemical Preparations.*
Boiling with sugar.	Syrup of acacia.	
ADDING MEDICATED LIQUID TO SYRUP.		
MEDICATING LIQUID.		
Aqueous solution.	Syrup of citric acid.	Syrup of ferrous iodide.
	Syrup of hydriodic acid.	
Fluidextract.	Syrup of rhubarb.	
	Syrup of sarsaparilla, compound.	
	Syrup of senega.	
	Syrup of senna.	
	Syrup of squill, compound.	
Tincture.	Syrup of rhubarb, aromatic.	
Diluted tincture.	Syrup of lactucarium.	
DISSOLVING SUGAR IN THE MEDICATING LIQUID.		
MEDICATING LIQUID.		
Aromatic water.	Syrup of orange flowers.	
Aqueous solution.	Syrup of hypophosphites.	Syrup of calcium lactophosphate.
	Syrup of tar.	
Infusion.	Syrup of wild cherry.	
Diluted tincture.	Syrup of orange.	
	Syrup of tolu.	
	Syrup of ginger.	
Diluted fluidextract.	Syrup of ipecac.	
Vinegar.	Syrup of squill.	

The table just given affords an insight into the many modifications necessary in preparing the official syrups, and we can now turn to a special consideration of the points regarding the official syrups, giving the same in alphabetic order.

SPECIAL NOTES ON OFFICIAL SYRUPS

SYRUPUS—Syrup

(Sirup—Simple Syrup)

Condensed Recipe.

Dissolve 850 Gm. sugar in enough distilled water to make 1 liter, either by hot solution or by cold percolation. The amount of water used at first in either method is 450 mils. For details, see U.S.P., p. 425.

Remarks.—Syrup, or what is commonly called *simple syrup*, is approximately a 65 per cent. solution of sugar in water. In 1000 mils (or 1313 grammes) of the syrup there are 850 grammes of sugar dissolved, hence the percentage strength is 850 ÷ 1313 or 64.7. It is prepared either by dissolving with boiling water or by percolation of water through sugar. The official syrup should have a specific gravity of about 1.313, and it is exceedingly poor economy to attempt to use a syrup much thinner than this. Syrups containing a smaller quantity of sugar will invariably ferment, and the apparent economy in saving a small quantity of sugar in making the syrup is more than counterbalanced by the necessity of throwing away a batch of spoiled syrup. If the syrup is properly prepared, there is no necessity for elaborate precautions of preserving the same, although it should, of course, be kept in well-stoppered bottles. Forch has studied the keeping qualities of simple syrup and other pharmacopœia syrups and has found that when properly prepared and stored the bacterial count is insignificant.

SYRUPUS ACACIÆ—Syrup of Acacia

(Syr. Acac.)

Condensed Recipe.

One hundred grammes of acacia are dissolved in 430 mils distilled water in an enameled or porcelain vessel. The mucilage is then heated on a water bath, with 800 Gm. sugar, until the latter is dissolved. Strain the hot syrup and add enough water to make a liter. Bottle while still hot in small sterilized containers. For details, see U.S.P., p. 426.

Remarks.—In this recipe, a syrup is made by boiling acacia and sugar in water as the product is likely to ferment, the pharmacopœia directing that it be stored in small tightly stoppered sterile bottles. Some pharmacists use it as a pill excipient, although pills so made are usually too hard.

SYRUPUS ACIDI CITRICI—Syrup of Citric Acid

(Syr. Acid. Cit.)

Condensed Recipe.

Ingredients.—Citric acid, 10 Gm.; distilled water and tincture of lemon peel, of each, 10 mils; syrup, enough to make 1 liter.

Manipulation.—Dissolve the acid in the water and add to the syrup. Then add the tincture and enough syrup to make a liter. For details, see U.S.P., p. 426.

Remarks.—This is approximately the average soda-fountain syrup of lemon, although that made from the fresh lemons is much to be preferred. Used entirely as a flavor. No dose given by the pharmacopœia.

SYRUPUS ACIDI HYDRIODICI—Syrup of Hydriodic Acid

This official derivative of hydriodic acid can best be explained in Part III. (p. 394).

SYRUPUS AURANTII—Syrup of Orange

(Syr. Aurant)

Condensed Recipe.

Ingredients.—Tincture of sweet orange peel, 50 mils; citric acid, 5 Gm.; sugar, 820 Gm.; distilled water enough to make 1 liter. Purified talc as clarifier.

Manipulation.—Triturate the tincture with the talc and with 400 mils of water, filter, dissolve the acid and the sugar in the filtrate, without heat and finally add enough water to make a liter. For details, see U.S.P., p. 427.

Remarks.—This is a very palatable flavoring syrup, hence no dose is assigned it in the pharmacopœia.

SYRUPUS AURANTII FLORUM—Syrup of Orange Flowers

(Syr. Aurant. Flor.)

Condensed Recipe.

Dissolve 850 Gm. sugar in enough orange flower water to make 1 liter, either by agitation or by percolation. In both cases, the sugar is first treated with 450 mils of the water. For details, see U.S.P., p. 428.

Remarks.—Another pleasant flavoring syrup.

SYRUPUS CALCII LACTOPHOSPHATIS—Syrup of Calcium Lactophosphate

This syrup will be considered among the derivatives of lactic acid (p. 610).

SYRUPUS FERRI IODIDI—Syrup of Ferrous Iodide

Fully described among the compounds of iron (Chapter XXXI).

SYRUPUS HYPOPHOSPHITUM—Syrup of Hypophosphites

(Syr. Hypophos.)

Condensed Recipe.

Ingredients.—Calcium hypophosphite, 45 Gm.; potassium and sodium hypophosphites, of each 15 Gm.; diluted hypophosphorous acid, 2 mils; glycerin, 50 mils; sugar, 600 Gm.; distilled water, enough to make 1 liter.

Manipulation.—Dissolve the hypophosphites in 500 mils of water, add the acid, filter, add the glycerin and the sugar to the filtrate, dissolve the sugar by cold agitation, lastly adding enough water to make a liter.

Remarks.—In the manufacture of this syrup, if any difficulty is found in dissolving the calcium hypophosphite, the fault is apt to lie in the salt, as a large amount of commercial calcium hypophosphite is not pure.

Dose.—10 mils (2½ fluidrachms).

SYRUPUS IPECACUANHÆ—Syrup of Ipecac

(Syr. Ipecac.)

Condensed Recipe.

Ingredients.—Fluidextract of ipecac, 70 mils; acetic acid, 10 mils; glycerin, 100 mils; sugar, 700 mils; water, enough to make 1 liter.

Manipulation.—Mix the acid with 300 mils of water and to the mixture add the fluidextract. Macerate twenty-four hours, filter and wash filter with enough water to make 450 mils. To this filtrate add the glycerin, dissolve the sugar in it, then add enough water to make 1 liter. The sugar may be dissolved either by cold agitation or by percolation. For details, see U.S.P., p. 431.

Remarks.—Note that while seven syrups (rhubarb, sarsaparilla compound, senega, senna, squill compound, ginger and ipecac) are made from the fluidextract, the first five are made by simply mixing the fluidextract with the syrup, while in making the last two the fluidextract is diluted with water and other ingredients, filtered, and sugar dissolved in the perfectly transparent filtrate. The latter process—shown in the recipe for syrup of ipecac—is much preferable merely to mixing the fluidextract with syrups (as in making syrup of rhubarb), which almost invariably yields a cloudy, unsightly product. In making syrup of ipecac, acetic acid is added to insure solution of the alkaloid, emetine.

Dose.—Expectorant, 1 mil (15 minims). Emetic, 15 mils (4 fluidrachms).

SYRUPUS LACTUCARII—Syrup of Lactucarium

(Syr. Lactucar.)

Condensed Recipe.

Ingredients.—Tincture of lactucarium, 100 mils; glycerin, 200 mils; citric acid, 1 Gm.; orange flower water, 50 mils; syrup, enough to make 1 liter.

Manipulation.—Dissolve the acid in the orange flower water. Mix the tincture with the glycerin and add to it the acid solution. After filtration add enough syrup to make 1 liter. For details, see U.S.P., p. 431.

Dose.—10 mils (2½ fluidrachms).

SYRUPUS PICIS LIQUIDÆ—Syrup of Tar

(Syr. Pic. Liq.)

Condensed Recipe.

Ingredients.—Tar, 5 Gm.; alcohol, 50 mils; magnesium carbonate, 10 Gm.; sugar, 850 Gm.; water, enough to make 1 liter.

Manipulation.—Triturate the tar dissolved in the alcohol with magnesium carbonate and 50 Gm. sugar; then add water filter, dissolve the rest of the sugar in the filtrate and lastly add to the strained syrup enough water to make 1 liter. The sugar is dissolved either by cold agitation or by percolation. For details, see U.S.P., p. 431.

Remarks.—In making this syrup the washed tar is dissolved in alcohol, triturated with magnesium carbonate and water, and then filtered. In the resulting tar water the sugar is dissolved. For general purposes, as in cough syrups, a syrup prepared from glycerole of tar (p. 767) (1 drachm glycerole to the fluidounce) is more convenient.

Dose.—4 mils (1 fluidrachm).

SYRUPUS PRUNI VIRGINIANÆ—Syrup of Wild Cherry

(Syr. Prun. Virg.)

Condensed Recipe.

Ingredients.—Wild cherry bark, 150 Gm.; sugar, 800 Gm.; glycerin, 50 mils; water, enough to make 1 liter.

Manipulation.—Percolate the bark with a mixture of glycerin and water. Dissolve the sugar in the percolate, either by cold agitation or by percolation. For details, see U.S.P., p. 432.

Remarks.—This syrup, which enjoys just popularity, is made by percolating wild cherry bark with a cold mixture of glycerin and water; dissolving sugar in the percolate thus obtained. In the former pharmacopœia (U.S.P. VIII) the bark was percolated with water, glycerin being added to the percolate, the idea being that a glycerin-water menstruum dissolved the tannin of the bark making a bitter syrup. After considerable controversy, the older method, the one used in U.S.P., 1890, was adopted for the present edition.

It is imperative that heat be avoided in making this syrup, since heat prevents the formation or causes the volatilization of the active principle, hydrocyanic acid. (See p. 706.)

Dose.—4 mils (1 fluidrachm).

SYRUPUS RHEI—Syrup of Rhubarb

(Syr. Rhei)

Condensed Recipe.

Ingredients.—Fluidextract of rhubarb, 100 mils; spirit of cinnamon, 4 mils; potassium carbonate, 10 Gm.; water, 50 mils; syrup, enough to make 1000 mils.

Manipulation.—Mix the spirit with the fluidextract, add the potassium carbonate dissolved in the water, lastly add the syrup. For details, see U.S.P., p. 433.

Remarks.—Syrup of rhubarb is prepared from the fluidextract of rhubarb and spirit of cinnamon, potassium carbonate being employed to aid in dissolving the difficultly soluble resins found in the rhubarb. An aqueous solution is thus obtained, in which the requisite amount of sugar is dissolved. This syrup is a laxative, while *aromatic syrup of rhubarb* is chiefly astringent, the aromatic it contains bringing about this different action. More concerning this therapeutic difference will be said when the drug, rhubarb, is discussed.

Dose.—10 mils (2½ fluidrachms).

SYRUPUS RHEI AROMATICUS—Aromatic Syrup of Rhubarb

(Syr. Rhei Arom.—Spiced Syrup of Rhubarb)

Condensed Recipe.

Dissolve 1 Gm. potassium carbonate in 150 mils aromatic tincture of rhubarb and then add enough syrup to make 1 liter.

Remarks.—This syrup is made by mixing syrup with aromatic tincture of rhubarb, previously rendered alkaline with potassium carbonate. The alkali is employed for the same reason as in making syrup of rhubarb. Turn to aromatic tincture of rhubarb (p. 232), and note what aromatics it contains.

Dose.—10 mils (2½ fluidrachms).

SYRUPUS SARSAPARILLÆ COMPOSITUS—Compound Syrup of Sarsaparilla

(Syr. Sarsap. Co.)

Condensed Recipe.

Ingredients.—Fluidextract of sarsaparilla, 200 mils; fluidextracts of glycyrrhiza and senna, of each 15 mils; oils of sassafras and anise, of each 0.2 mil; methyl salicylate, 0.2 mil; alcohol; syrup enough to make 1 liter.

Manipulation.—Dissolve the oils in the alcohol, add the fluidextracts and then mix with the syrup. For details, see U.S.P., p. 434.

Remarks.—*Compound syrup of sarsaparilla* affords a good test of memory, and its constituents form a question of which examining boards are quite fond. Note the three fluidextracts and the three oils used in its manufacture. The uses of the syrup as an adjuvant, especially for quinine, are well known.

Dose.—15 mils (4 fluidrachms).

SYRUPUS SCILLÆ—Syrup of Squill

(Syr. Scill.)

Condensed Recipe.

Dissolve 800 Gm. sugar in 450 mils vinegar of squill by gentle heat and finally add enough water to make 1 liter.

Remarks.—Syrup of squill is now made by dissolving sugar in vinegar of squill at gentle heat. In the pharmacopœia of 1890 the vinegar of squill was first boiled and filtered; this is not now necessary, since the boiling is performed in the manufacture of the official vinegar. (See p. 255.)

Dose.—2 mils (30 minims).

SYRUPUS SCILLÆ COMPOSITUS—Compound Syrup of Squill

(Syr. Scill. Co.—Hive Syrup)

Condensed Recipe.

Ingredients.—Fluidextracts of squill and senega, of each, 80 mils; antimony and potassium tartrate, 2 Gm.; distilled water; syrup, enough to make 1 liter.

Manipulation.—Dissolve the tartrate in warm water, add to syrup, then add the fluidextracts and lastly enough water to make 1 liter. For details, see U.S.P., p. 434.

Remarks.—Compound syrup of squill is made from the fluidextracts of squill and senega, the aqueous solution of the active principles of these drugs being filtered through purified talc, and to the clear filtrate a solution of tartar emetic is added, and in the resultant liquid sugar is dissolved. It is called *Coxe's hive syrup.*

Dose.—2 mils (30 minims).

SYRUPUS SENEGÆ—Syrup of Senega

(Syr. Seneg.)

Condensed Recipe.

Two hundred mils of fluidextract of senega are mixed with enough syrup to make 1 liter.

Remarks.—In preparing the fluidextract of senega (see p. 248) alkali is used to hold the pectin of the drug in solution, hence a syrup prepared from the fluidextract does not gelatinize as the old form of syrup did.

Dose.—4 mils (1 fluidrachm).

SYRUPUS SENNÆ—Syrup of Senna

(Syr. Senn.)

Condensed Recipe.

Five mils of oil of coriander are mixed with 250 mils of fluidextract of senna and then enough syrup is added to make 1 liter.

Remarks.—Note that the National Formulary gives recipes for a *compound syrup of senna* and for *aromatic syrup of senna;* as well as for *a compound syrup of figs,* which contains senna.

Dose.—4 mils (1 fluidrachm).

SYRUPUS TOLUTANUS—Syrup of Tolu

(Syr. Tolu.)

Condensed Recipe.

Fifty mils of tincture of tolu are triturated with 10 Gm. magnesium carbonate, 60 Gm. sugar and with water. The mixture is filtered and 760 Gm. sugar are dissolved in the filtrate by aid of gentle heat. The syrup is strained and the strainer is then washed with enough water to make 1 liter. The sugar may also be dissolved in the filtrate by cold percolation. For details, see U.S.P., p. 436.

Remarks.—The official recipe just given is substantially the process of the pharmacopœia of 1870, and yields a handsome aromatic yellow syrup. The process of 1880—digesting a mixture of balsam of tolu and sugar with water—was cumbersome and yielded a poor product, and the process of 1890—dissolving sugar in a water of tolu made by rubbing an alcoholic solution of the balsam with precipitated calcium phosphate and water—was not much better. The color is due to the fact that the alkaline magnesium carbonate acts on the resin of the balsam found in the tincture, producing a characteristic yellow tint.

Dose.—15 mils (4 fluidrachms).

SYRUPUS ZINGIBERIS—Syrup of Ginger

(Syr. Zingib.)

Condensed Recipe.

Thirty mils of fluidextract of ginger is dissolved in 20 mils of alcohol and the solution is triturated with 10 Gm. magnesium carbonate, 60 Gm. sugar and with water. The mixture is filtered and 760 Gm. sugar are dissolved in the filtrate as in making syrup of tolu.

Remarks.—Syrup of ginger is prepared like syrup of tolu, except that it is the fluidextract that is rubbed with magnesium carbonate and water and not the tincture.

Dose.—15 mils (4 fluidrachms).

Syrupus Amygdalæ (U.S.P. VIII) was prepared by mixing together 10 mils of spirit of bitter almond, 100 mils of orange flower water and 890 mils of syrup. This transparent preparation is quite different from the syrup of almond of the pharmacopœia of 1890, which was a milky liquid prepared from an emulsion of almond. It is popular as a flavor in the South under the name *orgeate sryup.*

Syrupus Ferri Quininæ et Strychininæ Phosphatum (U.S.P. VIII) is now found in the National Formulary. Although its method of manufacture is different from that given in the last pharmacopœia, the two products are practically identical. It is commonly called *Easton's syrup* and is an excellent tonic, although of rather limited popularity because of its intensely bitter taste. To make a stable preparation is a matter of difficulty, the usual product turning black and eventually precipitating. The dose is 4 mils (1 fluidrachm), containing about $\frac{1}{60}$ grain of strychnine.

Syrupus Hypophosphitum Compositus (U.S.P. VIII; N.F. IV) is a combination of the hypophosphites of calcium, potassium sodium, iron and manganese along with quinine and strychnine. It is given in doses of 8 mils (2 fluidrachms).

Syrupus Hypophosphitum cum Ferro (U.S.P. 1890) was the official syrup of hypophosphites combined with ferrous lactate. It was never very popular, compound syrup of hypophosphites being a much more satisfactory product.

Syrupus Rosæ (U.S.P. VIII; N.F. IV) is made by diluting fluidextract of rose with diluted sulphuric acid and water and then dissolving sugar in the filtered fluid. It is used as a flavor.

Syrupus Calcii Iodidi (N.F.), is prepared by first making a solution of ferrous iodide from iodine and iron wire and then treating this with precipitated calcium carbonate, when a solution of calcium iodide is obtained. In this, sugar is dissolved. *Dose.*—2 mils (30 minims.)

Syrupus Ferri et Mangani Iodidi (N.F.) is prepared by making a solution of ferrous iodide from iodine and iron wire and filtering directly into sugar; then making a solution of manganese iodide from manganese sulphate and sodium iodide and filtering this into the iron-sugar solution. *Dose.*—1 mil (15 minims).

Syrupus Iodotannicus (N.F.) is prepared by heating tannic acid, iodine and water in a flask provided with an upright condenser until the free iodine has become chemically combined with the other ingredients; then sugar is added. Power claims that the product is nothing else but an impure hydriodic acid. *Dose.*—4 mils (1 fluidrachm).

Syrupus Pini Strobi Compositus (with and without morphine). The National Formulary recognizes this popular cough remedy both with and without morphine; the former representing the latter, plus 0.5 Gm. of morphine sulphate to the liter. *Syrupus Pini Strobi Compositus* is prepared by percolating white pine bark, wild cherry, spikenard root, balm of Gilead buds, sanguinaria, sassafras bark and cudbear with a menstruum composed of glycerin, alcohol and water. In the percolate is dissolved sugar, oil of sassafras and chloroform (6 mils to the liter). The alcohol content is approximately 150 mils to the liter. The dose of the morphineless syrup is 4 mils (1 fluidrachm) while that containing morphine is 2 mils (30 minims).

Syrupus Rubi Idæi (N.F.) is the pleasant flavoring syrup of raspberry and the recipe given, like that of the pharmacopœia of 1890, directs that the syrup be prepared from the fresh fruit and not from the commercial fruit juice. The recipe should be read since it is a type formula which can be used for making most of the fruit syrups.

Syrupus Sennæ Aromaticus (N.F.) is prepared by percolating jalap, rhubarb, Saigon cinnamon, clove, nutmeg (previously mixed with oil of lemon) with diluted alcohol. The tincture is mixed with fluidextract of senna (125 mils to the liter) and then sugar is dissolved in the mixture. *Dose.*—8 mils (2 fluidrachms).

THE SYRUPS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Syrupus allii.	Syrup of garlic.	Fresh garlic, 200 Gm.; diluted acetic acid; sugar.	A preparation of the pharmacopœia of 1890.
Syrupus althææ.	Syrup of marshmallow.	Althæa root; water; alcohol, 30 mils; glycerin. 100 mils; sugar.	Keep in well-stoppered completely filled bottles.
Syrupus ammonii hypophosphitis.	Syrup of ammonium hypophosphite.	Ammonium hypophosphite, 35 Gm.; diluted hypophosphorous acid, distilled water, glycerin, sugar; compound spirit of vanillin as flavor.	*Dose.*—4 mils (1 fluidrachm).
Syrupus asari compositus.	Compound syrup of Canada snake root.	Asarum; cochineal; potassium carbonate; alcohol; water. Add to the tincture; fluidextract of ipecac; and sugar.	Used in whooping cough. *Dose.*—4 mils (1 fluidrachm). Used as vehicle for iodides.
Syrupus bromidorum.	Syrup of the bromides.	Bromides of potassium, sodium, ammonium, calcium, lithium; compound syrup of sarsaparilla; syrup. Tincture of vanilla as flavor; compound tincture of cudbear as color.	*Dose.*—4 mils (1 fluidrachm).
Syrupus calcii et sodii hypophosphitum.	Syrup of calcium and sodium hypophosphites.	Hypophosphites of calcium and sodium, of each 35 Gm.; hypophosphorous acid; sugar; water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus calcii hydrochlorophosphatis.	Syrup of calcium hydrochlorophosphate.	Precipitated calcium phosphate; hydrochloric acid; water; syrup; tincture of lemon peel.	*Dose.*—4 mils (1 fluidrachm).
Syrupus calcii hypophosphitis.	Syrup of calcium hypophosphite.	Calcium hypophosphite, 35 Gm.; hypophosphorous acid; sugar; water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus calcii iodidi.	Syrup of calcium iodide.	....	See p. 201.
Syrupus calcii lactophosphatis et ferri.	Syrup of calcium lactophosphate with iron.	Ferrous lactate, 8.5 Gm.; potassium citrate, 8.5 Gm.; water; syrup of calcium lactophosphate.	*Dose.*—4 mils (1 fluidrachm).
Syrupus cimicifugæ compositus.	Compound syrup of actæa.	Fluidextracts of cimicifuga, glycyrrhiza, senega and ipecac; wild cherry; sugar; water. Purified talc as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Syrupus cinnamomi.	Syrup of cinnamon.	Saigon cinnamon; alcohol, 50 mils; cinnamon water. Add to the percolate, sugar and cinnamon water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus codeinæ.	Syrup of codeine.	Codeine sulphate, 2 gm.; syrup.	*Dose.*—4 mils (66 minims).
Syrupus eriodictyi aromaticus.	Syrupus corrigens.	Fluidextract of eriodictyon; solution of potassium hydroxide; compound tincture of cardamom; oils of sassafras, lemon and clove; alcohol; water; magnesium carbonate. Dissolve sugar in the filtrate.	Used as a masker of the bitterness of quinine (see p. 760). *Dose.*—8 mils (2 fluidrachms).
Syrupus ferri et mangani iodidi	Syrup of iron and manganese iodides.	....	See p. 201.
Syrupus ferri hypophosphitis.	Syrup of ferric hypophosphite.	Ferric hypophosphite, 17.5 Gm; potassium citrate; sugar; orange flower water; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus ferri lactophosphatis.	Syrup of iron lactophosphate.	Ferrous lactate; phosphoric acid; sugar; syrup; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus ferri protochloridi.	Syrup of ferrous chloride.	Solution of ferrous chloride; glycerin; orange flower water; syrup.	*Dose.*—4 mils (1 fluidrachm).
Syrupus ferri, quininæ et strychninæ phosphatum.	Syrup of the phosphates of iron, quinine and strychnine	....	See p. 201.

THE SYRUPS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Syrupus ferri saccharati solubilis.	Syrup of the soluble oxide of iron.	Saccharated ferric oxide; syrup; water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus ficorum compositus.	Compound syrup of figs.	Figs, 300 Gm.; fluidextract of senna, 200 mils; aromatic fluidglycerate of cascara sagrada, 100 mils; oil of fennel; spirit of peppermint; sugar; water.	A pleasant purgative resembling a well-known proprietary. *Dose.*—4 mils (1 fluidrachm).
Syrupus glycyrrhizæ.	Syrup of licorice.	Fluidglycerate of glycyrrhiza; syrup.	A pleasant vehicle for bitter substances. *Dose.*—8 mils (2 fluidrachms).
Syrupus hypophosphitum compositus.	....	....	See p. 201.
Syrupus iodotannicus.	Syrup of iodotannin.	....	See p. 201.
Syrupus ipecacuanhæ et opii.	Syrup of Dover's powder.	Tincture of ipecac and opium, 85 mils; spirit of cinnamon; cinnamon water; syrup.	*Dose.*—4 mils (1 fluidrachm).
Syrupus krameriæ.	Syrup of krameria.	Fluidextract of krameria, 450 mils; syrup.	*Dose.*—4 mils (1 fluidrachm).
Syrupus mannæ	Syrup of manna.	Manna, 125 Gm.; alcohol, 65 mils; sugar; water.	*Dose.*—8 mils (2 fluidrachms).
Syrupus morphinæ et acaciæ.	Jackson's pectoral syrup.	Morphine hydrochloride 0.55 Gm.; oil of sassafras; syrup of acacia.	*Dose.*—4 mils (1 fluidrachm).
Syrupus papaveris.	Syrup of poppy capsules.	Poppy capsules, 100 gm.; made with a decoction in which dissolve sugar.	*Dose.*—4 mils (1 fluidrachm).
Syrupus phosphatum compositus.	Chemical food.	Compound solution of phosphates; syrup; glycerin. Colored with tincture of cudbear.	*Dose.*—4 mils (1 fluidrachm).
Syrupus phosphatum cum quinina et strychnina.	Compound syrup of hydrochlorophosphates.	Quinine hydrochloride, 4.4 Gm.; strychnine nitrate, 0.14 Gm.; compound solution of phosphates; glycerin, syrup.	*Dose.*—4 mils (1 fluidrachm).
Syrupus pini strobi compositus.	Compound syrup of white pine with and without morphine.	....	See p. 201.
Syrupus pini strobi compositus cum morphina.			
Syrupus quinidinæ.	Bitterless syrup of quinidine.	Quinidine, 33 Gm.; oil of orange peel; syrup.	*Dose.*—4 mils (1 fluidrachm).
Syrupus rhamni cathartici.	Syrup of buckthorn berries.	Fluidextract of rhamnus catharticus, 200 mils; oils of fennel and cinnamon; syrup.	Also called syrupus spinæ cervinæ. *Dose.*—8 mils (2 fluidrachms).
Syrupus rosæ.	....	....	See p. 201.
Syrupus rubi	Syrup of rubus.	Fluidextract of rubus, 250 mils; syrup.	Recognized in U.S.P. VIII. *Dose.*—4 mils (1 fluidrachm).
Syrupus rubi fructus	Syrup of blackberry fruit.	The juice of fresh ripe black-berries is mixed with sugar; the mixture is heated and the syrup is stored in sterile bottles.	Used as a flavor.
Syrupus rubi idæi.	....	....	See p. 201.
Syrupus sanguinariæ	Syrup of bloodroot.	Sanguinaria, 225 Gm., is percolated with a diluted acetic acid. In the evaporated percolate, sugar is dissolved.	*Dose.*—2 mils (30 minims).

THE SYRUPS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Syrupus sennæ aromaticus.	Aromatic syrup of senna.	....	*Dose.*—4 mils (1 fluidrachms).
Syrupus sennæ compositus.	Compound syrup of senna.	Fluidextracts of senna, rhubarb and frangula; methyl salicylate; alcohol, 65 mils; syrup.	*Dose.*—8 mils (2 fluidrachms).
Syrupus sodii hypophosphitis.	Syrup of sodium hypophosphite.	Sodium hypophosphite, 35 Gm.; hypophosphorous acid; sugar; water.	*Dose.*—4 mils (1 fluidrachm).
Syrupus stillingiæ compositus.	Compound syrup of stillingia.	Compound fluidextract of stillingia; glycerin; syrup.	*Dose.*—4 mils (1 fluidrachm).

DOSES OF OFFICIAL SYRUPS

1 mil (15 minims)	Syrups of ferrous iodide and of ipecac (as an expectorant).
2 mils (30 minims)	Syrups of squill, and squill compound.
4 mils (1 fluidrachm)	Syrups of hydriodic acid, senega, senna, tar, and wild cherry.
10 mils (2½ fluidrachms)	Syrups of calcium lactophosphate, hypophosphites, lactucarium, rhubarb, and rhubarb aromatic.
15 mils (4 fluidrachms)	Syrups of ginger, sarsaparilla compound, and tolu.

No dose given the official syrups not named above, as all the rest are flavored syrups and of no medicinal action.

HONEYS

Honeys are *liquids containing medicines blended with honey.* In ancient times the honeys represented the most popular class of medicinal preparations, but in our present day of elixirs and of syrups the honeys are falling into disuse, although one is still recognized by the pharmacopœia. Honey itself is the natural product stored in the honeycombs by the bees, as explained on p. 634.

MEL DEPURATUM—Clarified Honey

(Mel Depurat.)

Condensed Recipe.

Any convenient amount of honey is mixed with 2 per cent. of shredded paper pulp that has been washed and expressed and again shredded. The mixture is heated on a water-bath; the scum is removed, water is added to make up the loss of weight by evaporation and after straining 5 per cent. of its weight of glycerin is added.

Remarks.—Clarified honey—*Mel Despumatum* (U.S.P., 1890)—is natural honey, clarified by mixing with shreds of wetted filter-paper and heating on a water-bath, carefully removing the scum and filter-paper as it rises to the surface (p. 140). When the clarification is complete, the liquid is strained and mixed with 5 per cent. of glycerin in order to preserve it.

MEL ROSÆ—Honey of Rose

Condensed Recipe.

Fluidextract of rose (120 mils) is mixed with enough clarified honey to make 1000 Gm.

Remarks.—Honey of rose is prepared by blending 12 per cent. of fluidextract of rose with clarified honey. Honey of rose is used in preparation of *mass of mercury* (p. 302).

Dose.—4 mils (1 fluidrachm).

The National Formulary recognizes the following honeys:

Mel Rosæ et Sodii Boratis, containing sodium borate, 10 per cent.; glycerin and honey of rose.

Mel Sodii Boratis, or *Honey and Borax,* containing sodium borate, 10 per cent.; glycerin and clarified honey.

OXYMELS

Oxymels are liquid preparations in which the medicament is dissolved in or combined with a mixture of vinegar (or diluted acetic acid) and honey. They were important galenicals several centuries ago but at the present time there is practically only one survivor:

Oxymel Scillæ, N.F., which is prepared by mixing 50 Gm. of vinegar of squill with 100 Gm. of honey and then heating the mixture on a water-bath until it weighs 100 Gm.

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CHAPTER XIII

ELIXIRS, GLYCERITES, COLLODIONS, AND OLEATES

ELIXIRS

Elixirs are *hydro-alcoholic solutions of medicinal substances containing sugar.* Therefore, it can be seen that there is a slight analogy between them and syrups. In the latter, however, there is much more sugar. Considering the extensive use of elixirs, it may seem strange that so few have been introduced into the pharmacopœia, but two (aromatic elixir, and elixir of glycyrrhiza) being official.

The chief reason for this is that the comparatively large doses of these pleasant alcoholic preparations cause fear that they are more to be regarded as tipples than as true medicinal agents. Therefore, the pharmacopœial committee omitted the long line of these elegant pharmaceuticals, leaving them for incorporation in the National Formulary, and a full list of the elixirs found in that book are tabulated below.

But another word concerning elixirs; do not fear that they will spoil. If properly made, they improve with age, for time enables the alcohol and aromatics to blend, making a smoother, more pleasant preparation.

Preparation.—The manufacture of most elixirs consists in the dissolving of the medicinal ingredients in aromatic elixir, elixir of glycyrrhiza, compound elixir of almond, N.F., elixir of anise, N.F., red aromatic elixir, N.F., elixir of bitter orange, N.F., compound elixir of cardamom, N.F., aromatic elixir of yerba santa, N.F., aqueous elixir of glycyrrhiza, N.F., aromatic elixir of glycyrrhiza, N.F., compound elixir of taraxacum, N.F., compound elixir of vanillin, N.F., or some other pleasantly flavored basic elixir. Among the latter we find compound elixir of pepsin, N.F., while Scoville suggests an *aromatic chocolate elixir* containing chocolate, compound tincture of vanillin, coumarin and oils of orange, peppermint, anise, coriander, caraway, and ceylon cinnamon. The National Formulary gives a general monograph on elixirs suggesting niceties of preparation and storing of elixirs.

ELIXIR AROMATICUM—Aromatic Elixir

(Elix. Arom.—Simple Elixir)

Condensed Recipe.

Ingredients.—Compound spirit of orange, 12 mils; syrup, 375 mils; alcohol; distilled water enough to make 1 liter. Purified talc, as clarifier.

Manipulation.—The spirit is dissolved in 238 mils of alcohol; the syrup is added followed by 375 mils of water. To this fluid the talc is added and the mixture is filtered; the filter being washed with enough of a mixture of 1 volume of alcohol and 3 volumes of water to make 1 liter.

Remarks.—This is a pleasant flavored preparation, provided the compound spirit of orange (p. 180) is made from fine oils. It is the basis of most elixirs, among them the official *elixir of glycyrrhiza.*

ELIXIR GLYCYRRHIZÆ—Elixir of Glycyrrhiza

(Elix Glycyrrh.—Elixir Adjuvans, U.S.P. VIII—Elixir of Licorice)

Condensed Recipe.

Fluidextract of glycyrrhiza (125 mils) is mixed with enough aromatic elixir to make 1 liter.

Remarks.—This preparation was recognized in U.S.P. VIII under the name, *elixir adjuvans.* It originally appeared in the National Formulary and the name just given indicates that it is intended as a pleasant addition to mixtures of bitter drugs, the glycyrrhiza being an admirable mask for bitter substances. No dose is given by the pharmacopœia.

Elixir Ferri, Quininæ et Strychninæ Phosphatum (U.S.P. VIII) is prepared from soluble ferric phosphate, quinine, strychnine (0.275 Gm. to the liter) with the aid of phosphoric acid and of a solution of ammonium acetate (prepared from ammonium carbonate and acetic acid. The vehicle is aromatic elixir and much care has to be exercised in order to secure a handsome product. This obtained, its keeping qualities are far from good, so it was decided to drop the preparation both from the pharmacopœia and from the National Formulary.

Elixir Calcii Lactophosphatis (N.F.) is made by dissolving precipitated calcium carbonate in lactic and phosphoric acids and adding to the solution of lactophosphate thus formed, syrup, compound spirit of orange, alcohol and distilled water. Purified talc is used as a clarifying agent. *Dose.*—8 mils (2 fluidrachms).

Elixir Cinchonæ Alkaloidarum (N.F.) is a preparation rather poorly replacing the original elixir of calisaya, which was made by percolating calisaya bark and aromatics with a hydro-alcoholic menstruum, detannating the resulting tincture with fresh ferric hydroxide and adding to the detannated preparation, sugar, flavor and color. The Formulary product is made by dissolving the sulphates of quinine, cinchonine and cinchonidine in aromatic elixir; compound tincture of cudbear being used as color and purified talc as clarifier. Each liter contains 2 Gm. of the quinine and 1 Gm. each of the cinchonine and cinchonidine sulphates. From this elixir are prepared: I, *elixir cinchonæ alkaloidarum et ferri,* (35 Gm. ferric phosphate to the liter); II, *elixir cinchonæ alkaloidarum et hypophosphitum* (17.5 Gm. each of calcium and sodium hypophosphites to the liter); III, *elixir cinchonæ alkaloidarum, ferri et bismuthi* (65 mils of glycerite of bismuth to 1 liter of "II"); IV, *elixir cinchonæ alkaloidarum, ferri, bismuthi et strychninæ* (0.175 Gm. of strychnine sulphate to 1 liter of "III"); V, *elixir cinchonæ alkaloidarum, ferri et calcii lacto-phosphatis* (500 mils of syrup of calcium lactophosphate, potassium citrate and "II" to make 1 liter); *elixir cinchonæ alkaloidarum, ferri et pepsini* (200 mils of glycerite of pepsin mixed with 800 mils of "II") and *elixir cinchonæ alkaloidarum, ferri et strychninæ* (0.175 Gm. of strychnine sulphate to 1 liter of "II").

Elixir Digestivum Compositum (N.F. III) is a preparation containing pepsin, pancreatin, diastase, lactic and hydrochloric acids; glycerin, distilled water and aromatic elixir. It is colored red with cudbear and is clarified by use of purified talc. It is sometimes called compound elixir of pepsin and elixir of lactated pepsin and resembles preparatory articles of this character. It has been widely criticised by medical authorities (see p. 847) and for that reason was dropped in the last revision of the Formulary.

Cordiale Rubi Fructus (N.F.) or *blackberry cordial* resembles compound elixir of blackberry N.F. (see chart below). It is prepared by making a tincture by percolating Saigon cinnamon, clove and nutmeg with diluted alcohol, mixing this with syrup of blackberry. Purified talc is used as a clarifier.

THE ELIXIRS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Elixir amygdalæ compositum.	Compound elixir of almond.	Oil of bitter almond; vanillin; stronger orange flower water; alcohol, 50 mils; syrup; distilled water. Purified talc as clarifier.	This and the nine which follow are pleasantly flavored basic elixirs, which provide an admirable variety of flavors for the extemporaneous preparation of medicinal elixirs.
Elixir anisi.	Elixir of anise.	Anethol; oil of fennel; spirit of bitter almond; alcohol, 240 mils; syrup; distilled water. Purified talc as clarifier.	
Elixir aromaticum rubrum.	Red aromatic elixir.	Aromatic elixir, U.S.P., colored by maceration with cudbear.	
Elixir aurantii amari.	(Replacing elixir curassao N.F. III).	Oil of bitter orange; tincture of bitter orange peel; alcohol, 300 mils; stronger orange flower water; syrup; distilled water. Purified talc as clarifier.	
Elixir cardamomi compositum.	Compound elixir of cardamom.	Compound spirit of cardamom, 10 mils; alcohol, 90 mils; syrup; distilled water; purified talc as clarifier.	
Elixir eriodictyi aromaticum.	Elixir corrigens.	Fluidextract of eryodictyon; syrup; compound elixir of taraxacum. Pumice and magnesium carbonate as clarifiers.	
Elixir glycyrrhizæ aquosum.	Aqueous elixir of glycyrrhiza.	Fluidextract of glycyrrhiza, 150 mils; compound spirit of cardamom; stronger orange flower water; glycerin; syrup; distilled water.	
Elixir glycyrrhizæ aromaticum.	Aromatic elixir of glycyrrhiza.	Fluidextract of glycyrrhiza, 125 mils; oils of clove, cassia, myristica and fennel; aromatic elixir. Purified talc as clarifier.	
Elixir taraxaci compositum.	Compound elixir of taraxacum.	Fluidextracts of taraxacum, wild cherry and glycyrrhiza; tinctures of sweet orange peel, cinnamon and cardamom, compound; aromatic elixir.	
Elixir vanillini compositum.	Compound elixir of vanillin.	Compound spirit of vanillin, 20 mils; alcohol, 80 mils; glycerin; syrup; distilled water. Tincture of caramel as color and purified talc as clarifier.	
Elixir ammonii bromidum.	Elixir of ammonium bromide.	Ammonium bromide, 85 Gm.; syrup, distilled water; aromatic elixir.	*Dose.*—4 mils (1fluidrachm).
Elixir ammonii valeratis.	Elixir of ammonium valerate.	Ammonium valerate, 35 Gm.; chloroform, 1.5 mils; tincture of vanilla; aromatic elixir. Ammonia water enough to dissolve the valerate and compound tincture of cudbear as color.	*Dose.*—4 mils (1 fluidrachm).
Elixir bismuthi.	Elixir of bismuth.	Glycerite of bismuth; glycerin; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir buchu.	Elixir of buchu.	Fluidextract of buchu; alcohol; aromatic elixir. Purified talc as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Elixir buchu compositum	Compound elixir of buchu.	Compound fluidextract of buchu; aromatic elixir. Purified talc as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Elixir buchu et potassii acetatis	Elixir of buchu and potassium acetate.	Potassium acetate, 85 Gm.; elixir of buchu.	*Dose.*—4 mils (1 fluidrachm).
Elixir calcii bromidi.	Elixir of calcium bromide.	Calcium bromide, 85 Gm.; diluted hydrobromic acid; syrup; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir calcii et sodii glycerophosphatum.	Elixir of calcium and sodii glycerophosphates.	Glycerophosphates of calcium and sodium; phosphoric acid; glycerin; aromatic elixir; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Elixir calcii hypophosphitis.	Elixir of calcium hypophosphite.	Calcium hypophosphite, 35 Gm.; hypophosphorous acid; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).

THE ELIXIRS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Elixir calcii lactophosphatis.	Elixir of calcium lactophosphate.	....	See p. 206.
Elixir cascaræ sagradæ.	(Elixir rhamni purshianæ N.F. III).	Aromatic fluidextract of cascara sagrada, 500 mils; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir cascaræ sagradæ compositum.	Laxative elixir.	Aromatic fluidextract of cascara sagrada; fluidextracts of senna and juglans; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir catharticum compositum.	Compound cathartic elixir.	Fluidextracts of frangula, senna and rhubarb; spirit of peppermint; solution of potassium hydroxide; aromatic elixir.	*Dose.*—As aperient, 4mils (1fluidrachm) as cathartic 12 mils (3 fluidrachms).
Elixir cinchonæ alkaloidarum.	Elixir of calisaya alkaloids.	....	For this and its seven preparations, see p. 206.
Elixir corydalis compositum.	Compound elixir of corydalis.	Fluidextracts of corydalis, stillingia, xanthoxylum and iris; potassium iodide, 50 gm.; alcohol; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri hypophosphitis.	Elixir of ferric hypophosphites.	Ferric hypophosphite, 16.5 Gm.; potassium citrate; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri lactatis.	Elixir of iron lactate.	Iron lactate, 17.5 Gm.; potassium citrate; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri phosphatis.	Elixir of ferric phosphate.	Ferric phosphate, 35 Gm.; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri pyrophosphatis.	Elixir of ferric pyrophosphate.	Ferric pyrophosphate, 35 Gm.; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri pyrophosphatis, quininæ et strychninæ.	Elixir of pyrophosphate of iron, quinine and strychnine.	Ferric pyrophosphate, 35 Gm.; quinine sulphate, 8.75 Gm.; strychnine, 0.14 Gm.; citric acid; oil of orange peel; alcohol, syrup, distilled water. Ammonia water enough to insure neutrality.	*Dose.*—4 mils (1 fluidrachm).
Elixir ferri quininæ et strychninæ.	Elixir of iron, quinine and strychnine.	Tincture of ferric citrochloride; quinine hydrochloride; strychnine sulphate, 0.175 Gm.; alcohol; glycerin; distilled water. Compound spirit of orange as flavor and purified talc as clarifier.	This is *not* the elixir of the phosphates of iron, quinine and strychnine. See p. 206. *Dose.*—4 mils (1 fluidrachm).
Elixir formatum.	Elixir of formates.	Formic acid (225 Gm.), neutralised with the carbonates of sodium and potassium; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir formatum compositum.	Compound elixir of formates.	Formic acid (200 mils) neutralized with the carbonates of sodium, magnesium, strontium and lithium and the alkaloid quinine; alcohol; glycerin; distilled water. Compound spirit of cardamom and acetic acid as flavors; purified talc as clarifier.	*Dose.*—8 mils (2 fluidrachms).
Elixir gentianæ.	Elixir of gentian.	Fluidextract of gentian; sodium citrate; glycerin; syrup; alcohol; distilled water. Compound spirit of cardamom as flavor; purified talc as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Elixir gentianæ et ferri.	Elixir of gentian and iron.	Tincture of ferric citrochloride, 100 mils; elixir of gentian.	*Dose.*—4 mils (1 fluidrachm).
Elixir gentianæ et ferri phosphatis.	Elixir of gentian and ferric phosphate.	Ferric phosphate, 17.5 Gm.; distilled water; elixir of gentian.	*Dose.*—4 mils (1 fluidrachm).
Elixir gentianæ glycerinatum.	Glycerinated elixir of gentian.	Fluidextracts of gentian and taraxacum; tinctures of sweet orange peel and cardamom, compound; acetic ether, phosphoric acid; glycerin, sugar; sherry wine.	See p. 642. *Dose.*—8 mils (2 fluidrachms)

THE ELIXIRS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Elixir glycerophosphatum compositum.	Compound elixir of glycerophosphates.	Glycerophosphates of sodium; calcium, iron, manganese and quinine; strychnine; lactic acid; compound spirit of cardamom; alcohol; glycerin; water. Purified talc as a clarifier.	*Dose.*—8 mils (2 fluidrachms).
Elixir guaranæ.	Elixir of guarana.	Fluidextract of guarana, 200 mils; aromatic elixir; compound elixir of taraxacum.	*Dose.*—4 mils (1 fluidrachm).
Elixir humuli.	Elixir of hops.	Fluidextract of humulus, 125 mils; tincture of vanilla; compound elixir of taraxacum; aromatic elixir. Purified talc as clarifier.	*Dose.*—8 mils (2 fluidrachms).
Elixir hypophosphitum.	Elixir of hypophosphites.	Hypophosphites of calcium, sodium and potassium; hypophosphorous acid; distilled water; glycerin; compound spirit of cardamom; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir hypophosphitum et ferri.	Elixir of hypophosphites and iron.	Hypophosphites of calcium, sodium, potassium and iron; potassium citrate; hypophosphorous acid; distilled water; syrup; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir lithii bromidi.	Elixir of lithium bromidi.	Lithium bromide, 85 Gm.; syrup; distilled water; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir lithii citratis.	Elixir of lithium citrate.	Lithium citrate, 85 Gm.; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir lithii salicylatis.	Elixir of lithium salicylate.	Lithium salicylate, 85 Gm.; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir pepsini.	Elixir of pepsin.	Glycerite of pepsin, 200 mils; glycerin, hydrochloric acid; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir pepsini, bismuthi et strychninæ.	Elixir of pepsin, bismuth and strychnine.	Strychnine, 0.175 mils; tartaric acid; elixir of pepsin and bismuth.	*Dose.*—4 mils (1 fluidrachm).
Elixir pepsini et bismuthi.	Elixir of pepsin and bismuth.	Pepsin, 8.5 Gm.; glycerite of bismuth, 125 mils; glycerin, distilled water; tincture of caramel; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir pepsini et ferri.	Elixir of pepsin and iron.	Tincture of ferric citrochloride, 75 mils; elixir of pepsin.	*Dose.*—8 mils (2 fluidrachms).
Elixir pepsini et rennini compositum.	(Essentia pepsini N.F. III).	Pepsin, 22.5 Gm.; rennin, 16.5 Gm.; lactic acid, tincture of sweet orange peel; glycerin; alcohol, 200 mils; oil of myristica; distilled water. Purified talc as clarifier.	*Dose.*—8 mils (2 fluidrachms).
Elixir phosphori.	Elixir of phosphorus.	Phosphorus, 0.25 Gm.; chloroform, 5 mils; alcohol, 340 mils; glycerin; compound spirit of orange; oil of anise; distilled water. Purified talc as clarifier.	Same strength as elixir of phosphorus, U.S.P., 1890. *Dose.*—4 mils (1 fluidrachm).
Elixir phosphori et nucis vomicæ	Elixir of phosphorus and nux vomica.	Tincture of nux vomica, 3.5 mils; elixir of phosphorus.	*Dose.*—4 mils (1 fluidrachm).
Elixir potassii acetatis.	Elixir of potassium acetate.	Potassium acetate, 85 Gm.; aromatic elixir.	*Dose.*—15 mils (4 fluidrachms).
Elixir potassii acetatis et juniperi.	Elixir of potassium acetate and juniper.	Potassium acetate, 85 Gm.; fluidextract of juniper, 125 mils; aromatic elixir. Purified talc as clarifier.	*Dose.*—15 mils (4 fluidrachms).
Elixir potassii bromidi	Elixir of potassium bromide.	Potassium bromide; syrup; distilled water; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir quininæ valeratis et strychninæ.	Elixir of quinine valerate and strychnine.	Quinine valerate, 17.5 Gm.; strychnine sulphate, 0.175 Gm.; compound tincture of cudbear; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).

THE ELIXIRS OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Elixir rubi compositum.	Compound elixir of blackberry.	Rubus, nutgall, Saigon cinnamon, clove, mace and ginger are percolated with diluted alcohol. To the tincture syrup of blackberry is added.	*Dose.*—15 mils (4 fluidrachms).
Elixir sodii bromidi.	Elixir of sodium bromide.	Sodium bromide, 175 Gm.; syrup; distilled water; aromatic elixir.	*Dose.*—8 mils (2 fluidrachms).
Elixir sodii hypophosphitis.	Elixir of sodium hypophosphite.	Sodium hypophosphite, 35 Gm.; hypophosphorous acid; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir sodii salicylatis.	Elixir of sodium salicylate.	Sodium salicylate, 85 Gm.; syrup; distilled water; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir sodii salicylatis compositum.	Compound elixir of sodium salicylate.	Sodium salicylate; fluidextracts of cimicifuga and gelsemium; potassium iodide; aromatic elixir. Purified talc as clarifier.	*Dose.*—4 mils (1 fluidrachm).
Elixir strychninæ valeratis.	Elixir of strychnine valerate.	Strychnine valerate, 0.175 Gm.; distilled water; aromatic elixir. Tincture of vanilla as flavor and compound tincture of cudbear as color.	*Dose.*—4 mils (1 fluidrachm).
Elixir terpini hydratis.	Elixir of terpin hydrate.	Terpin hydrate, 17.5 Gm.; tincture of sweet orange peel; spirit of bitter almond; alcohol, 425 mils; glycerin; syrup; distilled water.	*Dose.*—4 mils (1 fluidrachm).
Elixir terpini hydratis et codeinæ.	Elixir of terpin hydrate and codeine.	Codeine, 2 Gm.; elixir of terpin hydrate.	*Dose.*—4 mils (1 fluidrachm).
Elixir terpini hydratis et diacetyl morphinæ.	(Elixir terpini hydratis cum heroina N.F. III)	Diacetyl morphine hydrochloride, 0.27 Gm.; elixir of terpin hydrate.	*Dose.*—4 mils (1 fluidrachm).
Elixir trium bromidorum.	Elixir of three bromides.	Bromides of ammonium, potassium and sodium; compound elixir of almond. Cudbear as color.	*Dose.*—4 mils (1 fluidrachm).
Elixir viburni opuli compositum.	Compound elixir of cramp bark.	Fluidextracts of viburnum opulus, trillium and aletris; compound elixir of taraxacum.	*Dose.*—4 mils (1 fluidrachm).
Elixir viburni prunifolii.	Elixir of black haw.	Fluidextract of viburnum prunifolium; compound tincture of cardamom; aromatic elixir.	*Dose.*—4 mils (1 fluidrachm).
Elixir zinci valeratis.	Elixir of zinc valerate.	Zinc valerate, 17.5 Gm.; citric acid; alcohol; spirit of bitter almond; compound tincture of cudbear; distilled water; aromatic elixir. Stronger ammonia water to neutralize the acid.	*Dose.*—4 mils (1 fluidrachm).

Vehiculæ is the name suggested by L. Emanuel for a class of preparations intended to serve as pleasant vehicles for medicinal substances and not having the objection possessed by elixirs; the fact that they are strongly alcoholic.

GLYCERITES

Glycerites (or *glycerols*) are *mixtures* or *solutions of medicinal substances with glycerin.* Most of them are solutions, but one of those official (glycerite of starch) is a semisolid mass. The glycerites are excellent preparations, being both permanent and emollient. However, they have the disadvantage of being smeary like their vehicles.

TABLE OF OFFICIAL GLYCERITES

Process.	*Galenic Preparations.*	*Chemical Preparation.*
Cold solution.	Glycerite of phenol.	
Warm solution.	Glycerite of tannic acid.	Glycerite of boroglycerin.
	Glycerite of starch.	
Percolation and solution.	Glycerite of hydrastis.	

SPECIAL NOTES ON OFFICIAL GLYCERITES

GLYCERITUM ACIDI TANNICI—Glycerite of Tannic Acid

(Glycer. Acid. Tan.—Glycerite of Tannin)

Condensed Recipe.
Tannic acid (20 Gm.) is dissolved in glycerin (80 Gm.) which has been warmed in a wide-mouthed bottle heated on a water-bath. For details, see U.S.P., p. 204.

Remarks.—Glycerite of tannic acid is a 20 per cent. solution of tannic acid in glycerin. It is hardly necessary to say that the use of metallic utensils should be rigidly avoided, as tannin combines with metals, particularly with iron, forming with that metal an inky black compound.

The glycerite when first prepared is of a brownish color, but on standing it assumes a deep green tint.

It is a convenient form for dispensing solutions of tannic acid, it being readily diluted by the addition of as much water as necessary.

Dose.—2 mils (30 minims).

GLYCERITUM AMYLI—Glycerite of Starch

(Glycer. Amyl.)

Condensed Recipe.
Ingredients.—Starch, 10 Gm.; water, 10 mils; glycerin, 80 Gm.
Manipulation.—The starch is triturated with the water, is added to the glycerin, warmed to 140°C. and the mixture is heated between 140° and 144° until a jelly forms. For details, see U.S.P., p. 204.

Glycerite of starch is a jelly containing 10 per cent. of starch, made by blending starch, water, and glycerin, and gently warming, with constant stirring, on a Bunsen burner to 144°C. to insure rupture of the starch granules. (See p. 632.) The stirring is necessary to avoid scorching.

Glycerite of starch is used as a basis of enemas and also as a pill excipient. Not being used internally, no dose is given by the pharmacopœia.

GLYCERITUM BOROGLYCERINI—Glycerite of Boroglycerin

(Glycer. Boroglyc.)

Condensed Recipe.
Ingredients.—Boric acid, 310 Gm.; glycerin, enough to make 1000 Gm.
Manipulation.—The boric acid is added to 460 Gm. glycerin that has been heated to 150°C. and the mixture is heated until it weighs 500 Gm. Mix this with 500 Gm. glycerin. For details, see U.S.P., p. 204.

Remarks.—Glycerite of boroglycerin contains 50 per cent. of boroglycerin (for calculations, see p. 613), and is a thick, viscid liquid, which is used externally as an antiseptic and emollient dressing. It is well to bear in mind that the addition of water to this glycerite causes precipitation of boric acid and that in making any dilution of this glycerite stronger than 1 part of acid to 18 parts of fluid, glycerin should be employed.

GLYCERITUM HYDRASTIS—Glycerite of Hydrastis

(Glycer. Hydrast.—Glycerite of Golden Seal)

One hundred mils of Glycerite of Hydrastis yields not less than 1.12 Gm. nor more than 1.37 Gm. of the ether-soluble alkaloids of hydrastis.

Condensed Recipe.
Ingredients.—Hydrastis, 1000 Gm.; glycerin, alcohol and water, of each enough to make 1000 mils.
Manipulation.—Percolate hydrastis with alcohol until it is exhausted. Distill off the alcohol from the percolate, pour the thick residual fluid into ice-cold water,

let stand for twenty-four hours, then filter, assay, and add water and glycerin to obtain a product containing 50 mils of glycerin and 1.25 Gm. alkaloids to each 100 mils. For details, see U.S.P., p. 205.

Remarks.—Glycerite of hydrastis is practically a glycerinic fluidextract of that important drug. It is prepared by percolating the drug with alcohol, evaporating off the alcohol, and blending the filtered residue with glycerin. It represents a form of "fluid hydrastis" so largely used as an ingredient of gonorrheal injections.

Dose.—2 mils (30 minims).

GLYCERITUM PHENOLIS—Glycerite of Phenol

(Glycer. Phenol.—Glycerite of Carbolic Acid)

Condensed Recipe.

Dissolve 20 mils of liquefied phenol in 80 mils of glycerin.

Remarks.—Glycerite of carbolic acid, as this preparation was called by the pharmacopœia of 1890, and as it is commonly called, contains 20 per cent. of liquefied phenol, and is an admirable antiseptic; for this purpose, however, it is too concentrated and more advantageous is the so-called *carbolated glycerin*, containing one fluidrachm of carbolic acid to the fluidounce of the finished product.

Dose.—0.3 mils (5 minims).

DOSES OF GLYCERITES

0.3 mil (5 minims)..............Glycerite of phenol.
2 mils (30 minims).............Glycerite of hydrastis and of tannic acid.

No dose given of glycerite of boroglycerin nor of glycerite of starch.

Glyceritum Bismuthi (N.F.) is a preparation representing 12.8 Gm. bismuth oxide to 100 mils made by treating a solution of bismuth subnitrate in a diluted nitric acid and mixing this with tartaric acid and sodium bicarbonate. The magma so obtained is washed after which it is heated with more tartaric acid and sodium bicarbonate until the resulting bismuth sodium tartrate has dissolved. To this solution glycerin and water are added.

Glyceritum Vitelli (N.F.) or *glyconin* is made by rubbing 45 Gm. of yolk of egg with 55 Gm. of glycerin. A thick yellow mixture results, which affords one of the most striking illustrations of the antiseptic action of glycerin. The writer has known a sample of glycerite of the yolk of egg five years old to be as sweet as when first made.

Glycerite of Elm has been suggested by Hommel as a vehicle for iodides and for creosote; while

Glycerite of Iodine containing 20 parts of iodine 20 parts of potassium iodide and 20 parts of glycerin is recommended by Apple.

GLYCERITES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Glyceritum bismuthi.	Glycerite of bismuth.		See above.
Glyceritum guaiaci.	Glycerite of guaiac.	Guaiac, 85 Gm.; solution of sodium hydroxide, 65 mils; glycerin; water.	*Dose.*—2 mils (30 minims).
Glyceritum pepsini.	Glycerite of pepsin.	Pepsin, 85 Gm.; hydrochloric acid; glycerin; distilled water. Purified talc as clarifier.	*Dose.*—3 mils (45 minims).
Glyceritum picis liquidæ.	Glycerite of tar.	Tar; glycerin; alcohol, 125 mils; water. Magnesium carbonate as clarifier.	*Dose.*—4 mils (1 fluidrachm). See p. 767.
Glyceritum tragacanthæ	Glycerite of tragacanth.	Tragacanth; glycerin; water.	See p. 304.
Glyceritum vitelli.	Glycerite of yolk of egg	....	See above.

COLLODIONS

These are *preparations used externally, having as their base collodion,* which liquid is a solution of pyroxylin (gun-cotton) in alcohol and ether (p. 630).

The solvent readily evaporates, leaving a film of gun-cotton, which is an excellent protective.

TABLE OF OFFICIAL COLLODIONS

(All Galenic)

Made by simple solution........	Collodion. Flexible collodion.
Made by percolation and solution..	Cantharidal collodion.

SPECIAL NOTES ON OFFICIAL COLLODIONS

COLLODIUM—Collodion

(Collod.)

Condensed Recipe.

Mix 40 Gm. pyroxylin with 250 mils alcohol and 750 mils ether. Shake until the pyroxlin is dissolved and decant clear fluid. For details, see U.S.P., p. 121.

Description.—Clear or slightly opalescent syrupy liquid; inflammable; evaporated in thin layer, leaves a film of pyroxylin. For details, see U.S.P.

Assay.—Precipitate out the pyroxylin by addition of an equal volume of water. Pyroxylin obtained should represent 5.1 per cent. of the collodion taken. For details, see U.S.P.

Remarks.—This ethereal solution of gun-cotton will be discussed later (p. 631).

COLLODIUM CANTHARIDATUM—Cantharidal Collodion

(Collod. Canth.—Blistering Collodion—Vesicating Collodion)

Condensed Recipe.

Ingredients.—Cantharides, 60 Gm., glacial acetic acid, 5 mils; flexible collodion, 85 Gm.; acetone, enough to make 100 Gm.

Manipulation.—Percolate the cantharides with mixture of the acetic acid and the acetone and finally with acetone until the drug is exhausted. Distil the acetone from the percolate and dissolve the residue in the flexible collodion. For details, see U.S.P., p. 122.

Remarks.—Cantharidal collodion is prepared by percolating cantharides with acetone, distilling the solvent from the percolate, and dissolving the remaining extracts in flexible collodion. The Swiss Pharmacopœia directs that this collodion be made from cantharidin.

COLLODIUM FLEXILE—Flexible Collodion

(Collod. Flex.)

Condensed Recipe.

Mix 950 Gm. collodion, 20 Gm. camphor and 30 Gm. castor oil and shake until the camphor is dissolved. For details, see U.S.P., p. 122

Remarks.—The pure pyroxylin layer left on evaporation of ordinary collodion is brittle and apt to crack when placed on the fingers and other joints. Flexible collodion, on the other hand, is made pliable by the addition of camphor and castor oil.

Note that as collodion is a solution of gun-cotton in a mixture of alcohol and ether, it will be precipitated by the addition of water. Therefore, a prescription containing collodion, tincture of iodine, and water of ammonia cannot be compounded, for as soon as the water of ammonia is added to the collodion, the pyroxylin separates in a wad. This can be remedied by substitution of the spirit of ammonia for water of ammonia.

All the collodions, since they contain ether, must be handled carefully and kept away from the flame.

COLLODIONS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 100 Gm.)	Remarks
Collodium iodi.	Iodine collodion.	Iodine, 5 Gm.; flexible collodion.	
Collodium iodoformi.	Iodoform collodion.	Iodoform, 5 gm., flexible collodion.	
Collodium salicylici compositum.	Compound salicylic collodion.	Salicylic acid, 11 Gm.; fluidextract of cannabis, 10 Gm.; flexible colldioon.	The well-known "corn solvent." See p. 761.
Collodium stypticum.	Styptic collodion.	Tannic acid, 20 Gm.; flexible collodion.	Was official in U.S.P. VIII.
Collodium tiglii.	Croton oil collodion.	Croton oil, 10 Gm.; flexible collodion.	A powerful local irritant, that must be used with caution.

OLEATES

These are *solutions of metallic oxides or alkaloids in oleic acid*, and, like ointments, produce the physiologic effect of the active ingredient through absorption of the latter on application to the skin by inunction.

They are prepared by dissolving an oxide or an alkaloid in oleic acid, and in making metallic oleates an excess of heat should be avoided, as oleic acid easily reduces the metallic oxides to the metals, particularly when the mixture is heated. The dissolving of the oxides in oleic acid is sometimes a rather difficult matter, and in order to obtain good results the oxide should be *in a very fine* powder and should be triturated with alcohol or shaken with ether prior to adding the oleic acid. The volatile fluid is, of course, evaporated after the oxide has dissolved. In making an oleate of an alkaloid, the free alkaloid and not the salts thereof should be used. All the oleates are, strictly speaking, chemical preparations, since the solvent (oleic acid) forms a salt (oleate) with either a metallic oxide or an alkaloid. Bear in mind, however, that the pharmaceutical oleates, now considered, are not definite chemicals, like sodium oleate (soap), lead oleate (lead plaster), or the other oleates discussed in Chapter XLI. The class we are now considering contains a large amount of oleic acid and, therefore, represent the definite chemical (the true oleate) dissolved in an excess of oleic acid.

OLEATUM HYDRARGYRI—Oleate of Mercury

(Oleat. Hydrarg.)

Condensed Recipe.

Ingredients.—Yellow mercuric oxide, 25 Gm.; alcohol, 20 mils; oleic acid, enough to make 100 Gm.

Manipulation.—Mix the oxide with the alcohol, add oleic acid, warm the mixture to 50°C. with stirring until the oxide has dissolved. For details, see U.S.P., p. 281.

Remarks.—This is the only oleate recognized in the present pharmacopœia; the others that were included in U.S.P. VIII, now being transferred to the National Formulary. It is used for extinguishing the mercury in the manufacture of mercurial ointment.

OLEATES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 100 Gm.)	Remarks
Oleatum aconitinæ.	Oleate of aconitine.	Aconitine, 2 Gm.; oleic acid; olive oil.	Distinctly irritating. Never apply to skin with the bare finger.
Oleatum atropinæ.	Oleate of atropine.	Atropine, 2 Gm.; oleic acid; olive oil. Alcohol used in aiding solution.	Was recognised in U.S.P. VIII.
Oleatum cocainæ.	Oleate of cocaine.	Cocaine, 5 Gm.; oleic acid; olive oil. Alcohol as a solvent of the alkaloid.	Ditto.
Oleatum quininæ.	Oleate of quinine.	Quinine, 25 Gm.; oleic acid.	Ditto. Used to obtain physiological effect of quinine by rubbing in at the armpits.
Oleatum veratrinæ.	Oleate of veratrine.	Veratrine, 2 Gm.; oleic acid; olive oil.	Was recognised in U.S.P. VIII.

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CHAPTER XIV

INFUSIONS, DECOCTIONS, AND TINCTURES

INFUSIONS

INFUSIONS are *preparations made by the maceration or percolation of vegetable substances with water.* With infusions we begin the study of those preparations made by extraction—by use of the processes of maceration and percolation—rather than by the simple solution of the medicating substance with the diluent.

In some of the official infusions the water used as the extracting solvent is applied cold, but usually it is poured on while boiling hot. It is used cold for such drugs as wild cherry, the active principle of which, hydrocyanic acid, would be driven off or its formation would be prevented by the temperature of boiling water.

Infusions are not much used in this country, American physicians preferring the alcoholic preparations of drugs, such as tinctures and fluidextracts.

They quickly spoil, and should be freshly prepared whenever called for, which is one reason why they have lost their popularity in this country. They are still largely used in England, and the various infusion mugs depicted in works of pharmacy are mostly of English design. Note that while only two infusions are official in the U.S.P., a general formula is given by which all unofficial infusions save those of potent drugs are to be prepared.

TABLE OF OFFICIAL INFUSIONS

Manufacture.	*Preparations.*
Maceration with hot water.	Infusion of digitalis.
	Infusion of senna, compound.
Percolation with cold water.	Infusion of wild cherry (U.S.P. VIII).

Explanatory of the table given above, it may be said that in making infusions by *hot maceration* the coarsely ground drug is put into a suitable vessel, boiling water is poured upon it, and the maceration permitted to continue a half-hour or an hour.

In England, where a dozen different infusions may be called for in a day's prescription business, those infusions in daily demand are prepared freshly each morning, and the special infusion mugs, such as are shown in Fig. 176, are in general use. In this country, where a prescription for an infusion comes in but rarely, any suitable glass or porcelain vessel —say, a teapot or a beaker—can be used. It is convenient to prepare the infusion by circulatory solution, that is, the ground drug is placed in a small piece of straining cloth and suspended just below the surface of the boiling water. It might be stated that the perforated diaphragm *a* of the infusion mug pictured above is intended for the same purpose. The process of *cold maceration* is sometimes employed in making infusions, but this is done rarely, and is not given official sanction. The process is identical with hot maceration, save that cold water is used. The process of *cold percolation* is directed for such drugs as wild cherry.

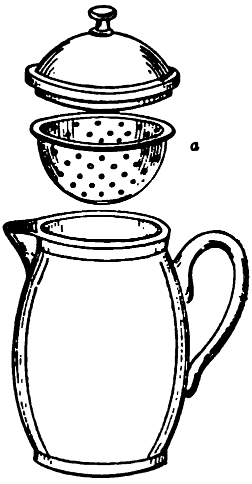

Fig. 176.—Infusion mug: *a*, Diaphragm.

The process of *hot percolation* is sometimes employed in making infusions, but is not given official sanction. It might, however, be mentioned that the first stage in the manufacture of the official fluidextracts of cascara sagrada (p. 246) and of triticum (p. 246) is the preparation of an infusion by percolation with hot water.

Infusions are sometimes prepared by *digestion*, that is, by allowing the drug to macerate in water several hours at gentle heat, such as that furnished by a steam radiator or found at the back of a wood-stove or coal-range.

But one word is necessary as to the preparation of infusions by diluting fluidextracts with warm water, a process recommended, for scarcely disinterested reasons, on the labels of the fluidextracts of most manufacturers. That necessary word is *don't!* The only reason an American physician prescribes an infusion is to get only those active principles of a drug which are soluble in water. If he wants those principles which are soluble in alcohol, he prescribes a tincture or a fluidextract. Hence for the pharmacist to dispense an infusion made from a fluidextract is as much a perversion of duty as would be the dispensing of a watery percolate from ginger on a prescription calling for the official tincture.

The *preservation* of infusions has been the subject of considerable unnecessary writing. By the very character of preparation, no attempts should be made to preserve infusions, which should be freshly prepared as required. The addition of any preservative agent to infusions is, of course, out of the question. In England, where the infusions are used very largely, a separate counter is arranged for the use of infusions, and here are placed a line of infusion mugs. At the beginning of each day the contents of these mugs are thrown away, and the apparatus carefully washed, and new quantities of the infusions are prepared. No infusion should be dispensed later than twenty-four hours after making.

SPECIAL NOTES ON OFFICIAL INFUSIONS

INFUSA—Infusions

Condensed Recipe.

This is a general formula directing that unless otherwise specified, an infusion should be made by macerating 50 Gm. of the coarsely comminuted drug with 1000 mils of boiling water for one-half hour, straining the mixture, and washing the strainer with enough water to make 1 liter. For details, see U.S.P., p. 226.

Remarks.—A "general formula" is an attempt to furnish a recipe for the manufacture of every representative of that particular line of preparations, the infusions, unless a special recipe is given by the pharmacopœia or by the physician, or unless the active ingredient is so potent that the preparation so made is dangerous.

Thus, a prescription for any infusion, save digitalis, and senna compound (those for which recipes are given in the National Formulary), or some very powerful drug, is expected to be compounded by the pharmacist according to the general formula. Thus a prescription for 1000 mils infusion of buchu is to be prepared by macerating 50 Gm. of the bruised drug with 1000 mils boiling water, and for any quantity the same proportion of buchu to boiling water (5 : 100) is to be preserved.

INFUSUM DIGITALIS—Infusion of Digitalis

(Inf. Digit.)

Condensed Recipe.

Ingredients.—Bruised digitalis, 15 Gm.; cinnamon water, 150 mils; water, enough to make a liter.

Manipulation.—Pour boiling water on the drug and macerate one hour. Strain, add the cinnamon water and wash strainer with enough water to make 1 liter. For details, see U.S.P., p. 227.

Remarks.—Infusion of digitalis contains 1½ per cent. of digitalis leaves, the strength of which is exhausted by maceration with boiling water, and the official product is then flavored with cinnamon water.

Dose.—4 mils (1 fluidrachm).

INFUSUM SENNÆ COMPOSITUM—Compound Infusion of Senna

(Inf. Senn. Co.)

Condensed Recipe.

Ingredients.—Senna, 60 Gm.; manna and magnesium sulphate, of each, 120 Gm.; fennel, 20 Gm.; water, enough to make 1 liter.

Manipulation.—Pour 800 mils of boiling water on the drugs. Macerate one-half hour, strain, dissolve the magnesium sulphate in the strained infusion. Lastly, add enough water to make 1 liter.

Remarks.—Compound infusion of senna is that old and popular remedy, "senna, manna, and salts," with a bit of fennel added for flavor. Note its synonym—*black draught;* this must not be confounded with "black drop" (p. 256), as it has been in truth, with fatal results.

Dose.—120 mils (4 fluidounces).

DOSES OF OFFICIAL INFUSIONS

4 mils (1 fluidrachm)	Infusion of digitalis.
120 mils (4 fluidounces)	Infusion of senna compound.

INFUSIONS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Infusum brayeræ.	Infusion of kooso.	Brayera, 60 Gm.; boiling water.	Do not strain. *Dose.*—250 mils (8 fluidounces).
Infusum cinchonæ.	Infusion of cinchona.	Cinchona, 60 Gm.; aromatic sulphuric acid; water.	Made by cold percolation. *Dose.*—50 mils (12 fluidrachms).
Infusum gentianæ compositum.	Compound infusion of gentian.	Gentian, 30 Gm.; coriander; bitter orange peel; diluted alcohol. Make a tincture and dilute with water.	*Dose.*—15 mils (4 fluidrachms).
Infusum pruni virginianæ.	Infusion of wild cherry.	Wild cherry, 40 Gm.; glycerin; water. Made by cold percolation.	Was recognised in U.S.P. VIII. *Dose.*—60 mils (2 fluidounces).
Infusum rosæ compositum.	Compound infusion of rose.	Red rose; diluted sulphuric acid; sugar; boiling water.	Chiefly used as a vehicle. *Dose.*—100 mils (3 fluidounces).

DECOCTIONS

These are *liquids made by boiling the drug for fifteen minutes or longer with water.*

The boiling should not be carried on in iron vessels, as a large number of drugs from which decoctions are made contain tannin, and this, combining with iron, forms a black mixture (ink). In Germany and other countries where the decoctions are popular they are prepared in special block-tin vessels; but in America, where the decoctions are but seldom prescribed, an enameled dish will answer the purpose.

The present pharmacopœia recognizes no specific decoctions, giving only the general formula, outlined below.

DECOCTA—Decoctions

Condensed Recipe.

A general formula directing the boiling of 50 Gm. of coarsely comminuted drug with 1000 mils of water for fifteen minutes. Express, strain and wash strainer with enough cold water to make 1 liter. For details, see U.S.P., p. 129.

Remarks.—The comments made regarding the general formula for infusions apply with equal force at this place.

The two decoctions recognized by the pharmacopœia of 1890 are worthy of the mention given below.

Decoctum Cetrariæ (U.S.P. 1890) is made by macerating 50 Gm. cetraria with 400 mils cold water for a half-hour and then the expressed liquid thrown away. The washed cetraria was then boiled with 1000 mils water for fifteen minutes.

Cetraria, or Iceland moss, contains a very bitter principle, called cetraric acid, as well as the mucilage, the constituent which makes the decoction a nutritious jelly. The presence of this bitter principle in the jelly would render it distasteful. Fortunately, however, cetraric acid is soluble in *cold* water, and for this reason the drug is first macerated in cold water, in which the cetraric acid will dissolve, this bitter liquid expressed and thrown away; then, and only then, can the cetraria be boiled to a jelly, free from bitterness.

Decoctum Sarsaparillæ Compositum (U.S.P. 1890; N.F. IV) made by boiling 100 Gm. bruised sarsaparilla and 20 Gm. guaiacum wood for a half-hour with 1000 mils water, then adding 20 Gm. sassafras bark, 20 Gm. glycyrrhiza, and 10 Gm. mezereum, and letting it macerate two hours. To the strained liquid enough water was added to make 100 mils.

This decoction, rarely used in this country, is popular in Germany as an alterative. It is called Zittmann's decoction.

TINCTURES

Tinctures are *alcoholic solutions of non-volatile substances* obtained by extraction of drugs.

An exception to the statement "alcoholic solutions of non-volatile substances" is found in tincture of iodine. The active ingredient of this is the volatile solid, iodine; but the presence of potassium iodide which is non-volatile brings the tincture practically within the definition given above.

Tinctures prepared from drugs differ from fluidextracts in the matter of strength. All fluidextracts, as we will learn later (p. 238), are adjusted to represent a 100 per cent. product, that is, 100 mils represent the active principles of 100 Gm. of a standard drug, while the tinctures are much weaker, none of those official being stronger than 50 per cent. The strength of tinctures varies, ranging from camphorated tincture of opium, which contains but 0.4 of 1 per cent. opium, its active ingredient, to tincture of lactucarium and other 50 per cent. tinctures.

The following table gives the strength of every tincture recognized by the present pharmacopœia.

STRENGTH OF OFFICIAL TINCTURES

0.4 of 1 per cent.: Tincture of opium, camphorated. 0.4 of 1 per cent. opium, 1.6 per cent. total active constituents.

5 per cent.: Tincture of musk.

7 per cent.: Tincture of iodine (also 5 per cent. potassium iodide).

10 per cent.: Tinctures of aconite, belladonna leaves, cannabis, cantharides, capsicum, colchicum seed, digitalis, gelsemium, hyoscyamus, kino, lobelia, nux vomica, opium, deodorized opium, physostigma, sanguinaria, squill, stramonium, strophanthus, and veratrum viride.

15 per cent.: Tincture of cardamom.

20 per cent.: Tinctures of arnica, asafetida, bitter orange, benzoin, calumba, cinchona, cinnamon, ginger, guaiac, guaiac ammoniated, hydrastis, myrrh, pyrethrum, quassia, tolu, valerian, and valerian ammoniated.

50 per cent.: Tinctures of lactucarium, lemon peel, and sweet orange peel.

Some official tinctures do not adapt themselves to the table just given, so must be given special mention.

Tincture of aloes	represents 10 per cent. aloes and 10 per cent. glycyrrhiza.
Tincture of ferric chloride	represents 35 per cent. solution of ferric chloride or 4.48 per cent. iron.
Tincture of lavender, compound	represents 0.8 per cent. oil of lavender and 5.5 per cent. total active constituents.
Tincture of rhubarb	represents 20 per cent. rhubarb and 4 per cent. cardamom.

The remaining official tinctures adjust themselves to the following table of strengths:

Name of Tincture	*Percentage of Principal Constituent*	*Percentage of Total Active Constituents*
Tincture of benzoin, compound	10 per cent.	24.0 per cent.
Tincture of cardamom, compound	2 per cent.	6.2 per cent.
Tincture of cinchona, compound	10 per cent.	20.0 per cent.
Tincture of gambir, compound	5 per cent.	7.5 per cent.
Tincture of gentian, compound	10 per cent.	15.0 per cent.
Tincture of rhubarb, aromatic	20 per cent.	30.0 per cent.

Explanatory of the above, let it be said that by "principal constituent" is meant the drug giving the compound tincture its name, and as to "total active constituents" these will be enumerated in the proper place.

Attention should be called to the distinction between "represents" and "contains;" thus, it can be said that tincture of vanilla, N.F., "represents 10 per cent. vanilla and contains 20 per cent. sugar." This distinction should always be borne in mind in discussing the strength of liquid pharmaceuticals, and it can only be said of any one of these that it "contains" a certain percentage of a drug when that drug is completely dissolved in the liquid, as in the case of the sugar in tincture of vanilla. If the drug is composed of vegetable tissue not entirely soluble in the menstruum, as in the case of the vanilla, then the tincture does not "contain" 10 per cent. vanilla, but merely represents the active principles obtained from 10 per cent. vanilla by extraction. There is another clumsy phase in the glib statement that a certain tincture is 10 per cent.; namely, a true 10 per cent. preparation is one in which all the ingredients are weighed, that is, represents 10 Gm. of drug in 100 Gm. of the finished product. On the other hand, a 10 per cent. tincture contains the activity of 10 Gm. of drug in 100 mils of finished tincture. This, however, is a question of splitting hairs, since in making the greater number of the liquid pharmaceuticals of the pharmacopœia the solids are weighed, while the preparation is finished by bringing it to a certain volume. Further attention must be called to the fact that the ultimate strength of many of the official tinctures is not based on percentage of drug represented but upon its chemical or biological assay.

Summing up the table of strengths of tinctures, we have one 5 per cent. tincture (two including gambir compound), one 7 per cent. tincture, one 15 per cent. tincture, and three 50 per cent. tinctures. The others are 10 per cent. or 20 per cent., and all those of potent drugs are 10 per cent. except iodine. Before dismissing the question of the strength of tinctures, mention should be made of the fact that tincture of kino has been changed from a 5 per cent. to a 10 per cent. preparation.

The following tables give lists of official tinctures arranged according to method of manufacture. In passing, it may be said that all of them are galenic preparations.

OFFICIAL TINCTURES MADE BY SOLUTION OR DILUTION

Preparation.	*Solvent.*
Tincture of ferric chloride	Alcohol, 650 mils; solution of ferric chloride, 350 mils.
Tincture of iodine	Alcohol, approximately 950 mils; water 50 mils.

OFFICIAL TINCTURES MADE BY MACERATION

Menstruum.	*Preparation.*
Alcohol, U.S.P.	Tincture of asafetida.
	Tincture of benzoin.
	Tincture of benzoin, compound.
	Tincture of guaiac.
	Tincture of lemon peel.
	Tincture of myrrh.
	Tincture of sweet orange.
	Tincture of Tolu.
Alcohol, 750 mils; water, 250 mils	Tincture of lavender, compound.
Diluted alcohol, U.S.P.	Tincture of aloes.
	Tincture of gambir, compound.
	Tincture of musk.
Glycerin, 50 mils; diluted alcohol, 950 mils	Tincture of cardamom, compound.
Glycerin, 40 mils; diluted alcohol, 950 mils	Tincture of opium, camphorated.
Aromatic spirit of ammonia	Tincture of guaiac, ammoniated.

OFFICIAL TINCTURE MADE BY DIGESTION AND MACERATION

Menstruum.	*Preparation.*
Water 500 mils; then alcohol, 500 mils.	Tincture of kino.

OFFICIAL TINCTURES MADE BY PERCOLATION

Menstruum.	*Preparation.*
Alcohol, U.S.P.	Tincture of cannabis.
	Tincture of ginger.
	Tincture of physostigma.
	Tincture of pyrethrum.
	Tincture of strophanthus.
	Tincture of veratrum viride.
Alcohol, 950 mils; water, 500 mils	Tincture of capsicum.
	Tincture of digitalis.
	Tincture of nux vomica.
	Tincture of squill.
	Tincture of valerian.
Alcohol, 750 mils; water, 250 mils	
Alcohol, 700 mils; water, 300 mils	Tincture of aconite.
Alcohol, 666 mils; water, 333 mils	Tincture of hydrastis.
Alcohol, 650 mils; water, 350 mils	Tincture of gelsemium.
Alcohol, 600 mils; water, 400 mils	Tincture of bitter orange.
	Tincture of calumba.
	Tincture of colchicum seed.
Diluted alcohol, U.S.P.	Tincture of arnica.
	Tincture of belladonna leaves.
	Tincture of cardamom.
	Tincture of hyoscyamus.
	Tincture of lobelia.
	Tincture of opium.
	Tincture of stramonium.
Alcohol, 333 mils; water, 666 mils	Tincture of quassia.
Alcohol, 200 mils; water, 800 mils	Tincture of deodorized opium.
Glycerin, 75 mils; alcohol, 675 mils; water, 250 mils	Tincture of cinchona.
	Tincture of cinchona, compound.
	Tincture of cinnamon.
Glycerin, 250 mils; alcohol, 500 mils; water, 250 mils	Tincture of lactucarium
Glycerin, 100 mils; alcohol, 500 mils; water, 400 mils	Tincture of gentian, compound.
	Tincture of rhubarb.
	Tincture of rhubarb, aromatic.
Hydrochloric acid, 20 mils; alcohol, 600 mils; water, 400 mils	Tincture of sanguinaria.
Aromatic spirit of ammonia	Tincture of valerian, ammoniated.

OFFICIAL TINCTURE MADE BY DIGESTION AND PERCOLATION

Menstruum.	*Preparation.*
Alcohol, U.S.P.	Tincture of cantharides.

As to the three methods of preparing tinctures given in the table, no better explanation can be given than that provided in the general formula which is provided in the present pharmacopœia, which the student should carefully read.

In percolating tinctures containing glycerin it is customary to use the menstruum specified above as a primal menstruum and at the end of the process to use mixtures of alcohol and water.

TINCTURÆ—Tinctures

Condensed Recipe.

This is a general formula outlining the manufacture of tinctures by percolation and by maceration. For details, see U.S.P., p. 444.

Remarks.—Tinctures are prepared by maceration only when percolation is not advisable. This is the case with a resinous drug which if packed in a percolator and treated with alcohol would become a sticky mass, clogging the percolator. With such a drug percolation is only possible, if it is mixed with more than its own weight of clean dry sand. As to the choice of menstrua, this was already discussed on p. 162, so here it need only be said, on comparison of the above table of menstrua with the discussion of the chemical constituents of the drugs employed, found in Part IV., it will be usually found that the drugs requiring strong alcohol for extraction are those grouped among resins, gum-resins, oleoresinous, or volatile oil drugs; that those extracted with glycerinic menstruum are tannin-bearing drugs; that those having acetic acid in the menstruum are drugs containing volatile alkaloids; while the ordinary drug containing glucosides, neutral principles, or stable alkaloids are extracted with alcohol more or less diluted with water.

There are 54 tinctures recognized by the present pharmacopœia—10 less than were recognized by U.S.P. VIII.

SPECIAL NOTES ON OFFICIAL TINCTURES

TINCTURA ACONITI—Tincture of Aconite

(**Tr. Aconit**—Aconiti tinctura P.I.)

One hundred mils of Tincture of Aconite yields not less than 0.045 Gm. nor more than 0.055 Gm. of the ether-soluble alkaloids of aconite. If assayed biologically the minimum lethal dose should not be greater than 0.0004 mil for each gramme of body weight of guinea-pig.

Condensed Recipe.

Moisten 100 Gm. of drug in No. 60 powder with a sufficient amount of the menstruum—alcohol, 7 volumes; water, 3 volumes; macerate for six hours before and twenty-four hours after packing and percolate until 950 mils of tincture are obtained. A part of this is assayed and the rest is adjusted to the official alkaloidal strength (0.045 to 0.055 Gm. alkaloids) by addition of the menstruum mentioned above. For details, see Type Process, P, as modified for assayed tinctures, U.S.P., p. 444.

Remarks.—The assay of this tincture will be explained in Chapter LV. It should contain $^{45}/_{1000}$ to $^{55}/_{1000}$ of 1 per cent. aconitine.

Dose.—0.3 mil (5 minims).

TINCTURA ALOES—Tincture of Aloes

(**Tr. Aloes**)

Condensed Recipe.

Aloes (100 Gm.) and glycyrrhiza (200 Gm.) are macerated with diluted alcohol for three days. The mixture is then filtered and the filter washed with enough diluted alcohol to make 1 liter. For details, see Type Process M, U.S.P., p. 445.

Remarks.—This represents, besides the chief ingredient, 20 per cent. licorice root. Note that this and all tinctures prepared by maceration are directed to be filtered either through absorbent cotton or through a plain filter, plaited filters not being advised.

Dose.—2 mils (30 minims).

TINCTURA ARNICÆ—Tincture of Arnica

(Tr. Arnic.)

Condensed Recipe.

Arnica (200 Gm.) is percolated with diluted alcohol until 250 mils of percolate are obtained. Then macerate for twenty-four hours and then percolate another 250 mils of tincture. Continue this interrupted percolation until a liter of tincture is obtained. For details, see U.S.P., p. 446.

Remarks.—This preparation was called *tincture of arnica flowers* by the pharmacopœia of 1890, since at that time a *tincture of arnica root* was official. It will be noted that the official recipe given above directs interrupted percolation; that is, the percolation is stopped three times in order to permit new portions of menstruum (diluted alcohol) to act by maceration upon the partly extracted drug. In U.S.P. VIII, fractional maceration followed by expression was employed—a wise provision since the drug is very bulky and highly absorbent; hence percolation means a large waste of menstruum, unless the marc is expressed. The popularity of tincture of arnica as a vulnerary is well known. It is rarely given internally.

Dose.—1 mil (15 minims).

TINCTURA ASAFŒTIDÆ—Tincture of Asafetida

(Tr. Asafœt.)

Condensed Recipe.

Made by maceration of asafetida with alcohol. Strength, 20 per cent. Details as in making tincture of aloes.

Dose.—1 mil (15 minims).

TINCTURA AURANTII AMARI—Tincture of Bitter Orange Peel

(Tr. Aurant. Amar.)

Condensed Recipe.

Moisten 200 Gm. of drug in No. 40 powder with a sufficient amount of the menstruum alcohol, 600 mils; water, 400 mils; macerate six hours before and twenty-four hours after packing and then percolate to 1000 mils. For details, see Type Process P., U.S.P., p. 444.

Dose.—4 mils (1 fluidrachm).

TINCTURA AURANTII DULCIS—Tincture of Sweet Orange Peel

(Tr. Aurant. Dulc.)

Condensed Recipe.

Five hundred grammes freshly grated sweet orange peel and macerated with 1000 mils of alcohol for three days, after which the mixture is filtered through purified cotton, the filter being washed with enough alcohol to make 1 liter. For details, see U.S.P., p. 223.

Remarks.—This tincture is a pleasant flavor, more like a spirit than a tincture.

Dose.—4 mils (1 fluidrachm).

TINCTURA BELLADONNÆ FOLIORUM—Tincture of Belladonna Leaves

(Tr. Bellad. Fol.)

Condensed Recipe.

Moisten 100 Gm. of drug in No. 60 powder with the menstruum; macerate and percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—For the assay of this tincture, see Chapter LV. It should contain $^{27}/_{1000}$ to $^{33}/_{1000}$ of 1 per cent. of mydriatic alkaloids.

Dose.—0.75 mils (12 minims).

TINCTURA BENZOINI—Tincture of Benzoin

(Tr. Benz.)

Condensed Recipe.

Macerate 200 Gm. of benzoin in No. 40 powder with enough alcohol to make 1000 mils. Details as in making tincture of aloes.

Remarks.—Tincture of benzoin is now used largely in steam inhalers for bronchial troubles.

Dose.—1 mil (15 minims).

TINCTURA BENZOINI COMPOSITA—Compound Tincture of Benzoin

(Tr. Benz. Co.)

Condensed Recipe.

Ingredients.—Benzoin, 100 Gm.; aloes, 20 Gm.; storax, 80 Gm.; balsam of tolu, 40 Gm.; alcohol, enough to make 1 liter.

Manipulation.—Macerate as in making tincture of aloes.

Remarks.—This useful preparation is similar to, but not identical with, the old-time proprietaries: *friars' balsam, Turlington's balsam, elixir commendatoris,* or *baume de commandeur.* The latter product contained balsam of Peru, myrrh, and angelica root, in addition to the ingredients of the official tincture. A recipe for the true friars' balsam is found in the National Formulary, but it is usually the custom in this country to dispense compound tincture of benzoin on calls for the preparations whose synonyms have just been given.

Dose.—2 mils (30 minims).

TINCTURA CALUMBÆ—Tincture of Calumba

(Tr. Calum.)

Condensed Recipe.

Moisten 200 Gm. drug in No. 20 powder with the menstrum—600 mils of alcohol; 400 mils of water—macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Dose.—4 mils (1 fluidrachm).

TINCTURA CANNABIS—Tincture of Cannabis

(Tr. Cannab.)

Condensed Recipe.

Moisten 100 Gm. of the drug in No. 40 powder with the menstruum—alcohol U.S.P.; macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Remarks.—This was called *tincture of cannabis indica* in U.S.P. VIII, as in that standard only Indian hemp could be employed. In the present pharmacopœia (see p. 760), American as well as Indian hemp, is included under the title "cannabis." Note that the tincture is to be physiologically assayed. (See Chapter LV.)

Dose.—0.75 mil (12 minims).

TINCTURA CANTHARIDIS—Tincture of Cantharides

(Tr. Canthar.—Cantharidis tinctura P. I.)

Condensed Recipe.
Cantharides (100 Gm.) is digested with alcohol in a strong tin container provided with a safety tube for twenty-four hours between 50° and 55°C. The mixture is then percolated with alcohol until 1 liter of tincture is obtained. For details, see U.S.P., p. 450.

Remarks.—The object of digestion prior to percolation is to insure complete extraction of the cantharidin. The use of the tincture as a scalp stimulator in hair dressings is well known.

Dose.—0.1 mil (1½ minims).

TINCTURA CAPSICI—Tincture of Capsicum

(Tr. Capsic.)

Condensed Recipe.
Moisten 100 Gm. of the drug in No. 50 powder with the menstruum—950 mils alcohol; 50 mils water; macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Dose.—0.5 mil (8 minims).

TINCTURA CARDAMOMI—Tincture of Cardamom

(Tr. Cardam.)

Condensed Recipe.
Moisten 150 Gm. of cardamom seed in No. 40 powder with the menstruum—diluted alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Dose.—2 mils (30 minims).

TINCTURA CARDAMOMI COMPOSITA—Compound Tincture of Cardamom

(Tr. Cardam Co.)

Condensed Recipe.
Macerate 20 Gm. cardamon seed; 25 Gm. Saigon cinnamon; 12 Gm. caraway, and 5 Gm. cochineal, with the menstruum—glycerin, 50 mils; diluted alcohol, 950 mils; finally using enough diluted alcohol to make 1000 mils. Details as in making tincture of aloes.

Remarks.—A mnemonic for the active constituents of this compound tincture are the four C's:

C ardamom
innamon
araway
ochineal

This bright-red liquid—the color due to the cochineal—is a pleasant aromatic and carminative.

Dose.—4 mils (1 fluidrachm).

TINCTURA CINCHONÆ—Tincture of Cinchona

(Tr. Cinch.)

One hundred mils of Tincture of Cinchona yields not less than 0.8 Gm. nor more than 1.0 Gm. of the total alkaloids of cinchona.

Condensed Recipe.
Cinchona (200 Gm.) is percolated with a primal menstruum consisting of 75 mils of glycerin, 675 mils of alcohol and 250 mils of water, completing the percolation with a mixture of two volumes of alcohol and one volume of water. Details as in making tincture of aconite.

For Assay, see U.S.P., p. 451 and also Chapter LV.

Remarks.—In this case, the percolation differs from that in making tincture of aconite, since the same menstruum is not used through the entire process. That is, in making a liter of tincture, when, after the liter of glycerinic menstruum is used up (for, bear in mind, more than one liter of menstruum has to be used to get a liter of percolate), the percolation is continued with a mixture of alcohol and water (hydroalcoholic menstruum) until the liter of finished product is obtained. Since this statement is applied to all tinctures made by percolation of drug with glycerinic menstruum, the above recipe is typical.

The pharmacopœial assay for this tincture is given in Chapter LV. It should contain 0.8 to 1.0 per cent. of total cinchona alkaloids.

Dose.—4 mils (1 fluidrachm).

TINCTURA CINCHONÆ COMPOSITA—Compound Tincture of Cinchona

(Tr. Cinch. Co.)

Condensed Recipe.

Moisten 100 Gm. red cinchona, 80 Gm. bitter orange peel, and 20 Gm. serpentaria, with the same menstruum used in making tincture of cinchona, and proceed to percolate to 1000 mils, as in making the latter tincture.

Remarks.—This is sometimes called Huxham's tincture of bark, and is a valuable tonic. It should not be dispensed with iron preparations, since the cinchotannic acid present in the bark reacts with iron to form an inky mixture.

Dose.—4 mils (1 fluidrachm).

TINCTURA CINNAMOMI—Tincture of Cinnamon

(Tr. Cinnam.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 50 powder with the menstruum, the same as used in the cinchona tinctures; macerate and proceed to make 1000 mils tincture by percolation, as in making tincture of cinchona.

Dose.—2 mils (30 minims).

TINCTURA COLCHICI SEMINIS—Tincture of Colchicum Seed

(Tr. Colch. Sem.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 50 powder with the menstruum—alcohol, 600 mils; water, 400 mils; macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—The assay of this tincture will be found in Chapter LV. It should contain from $^{36}/_{1000}$ to $^{44}/_{1000}$ of 1 per cent. of colchicine.

Dose.—2 mils (30 minims).

TINCTURA DIGITALIS—Tincture of Digitalis

(Tr. Digit.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 60 powder with the menstruum—alcohol, 750 mils; water, 250 mils; macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Remarks.—The tincture of digitalis contains an appreciable amount of fat naturally existing in the leaves, and of late years efforts have been made to introduce the so-called fat-tree tincture of digitalis. Such a tincture is prepared by first removing the fat from the drug by percolation with chloroform. Note that the tincture may be biologically assayed. (See Chapter LV.)

Dose.—0.5 mil (8 minims).

TINCTURA FERRI CHLORIDI—Tincture of Ferric Chloride

This preparation can best be discussed among the salts of iron. (See p. 510.)

TINCTURA GAMBIR COMPOSITA—Compound Tincture of Gambir

(Tr. Gambir Co.)

Condensed Recipe.

Macerate 50 Gm. gambir and 25 Gm. Saigon cinnamon both in a No. 50 powder, with enough diluted alcohol to make 1000 mils tincture. Details as in making tincture of aloes.

Remarks.—This official replaces the formerly official *tincture of catechu,* being identical with it, save the use of pale catechu (gambir), instead of the catechu from the plant *Acacia catechu.* (See p. 719.)

Dose.—4 mils (1 fluidrachm).

TINCTURA GELSEMII—Tincture of Gelsemium

(Tr. Gelsem.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 60 powder with the menstruum—alcohol, 650 mils; water, 350 mils; macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Dose.—0.25 mils (4 minims).

TINCTURA GENTIANÆ COMPOSITA—Compound Tincture of Gentian

(Tr. Gentian Co.)

Condensed Recipe.

Moisten 100 Gm. gentian, 40 Gm. bitter orange peel, and 10 Gm. cardamon seed all in a No. 40 powder, with the menstruum—glycerin, 100 mils; alcohol, 500 mils; water, 400 mils; macerate and then percolate, using diluted alcohol as the last menstruum. Details as in making tincture of bitter orange peel.

Dose.—4 mils (1 fluidrachm).

TINCTURA GUAIACI—Tincture of Guaiac

(Tr. Guaiac)

Condensed Recipe.

Macerate 200 Gm. of the drug in a No. 40 powder with enough alcohol (U.S.P.) to make 1000 mils of the tincture. Details as in making tincture of aloes.

Dose.—4 mils (1 fluidrachm).

TINCTURA GUAIACI AMMONIATA—Ammoniated Tincture of Guaiac

(Tr. Guaiac. Ammon.)

Condensed Recipe.

Macerate 200 Gm. guaiac in a No. 40 powder with enough aromatic spirit of ammonia to make 1000 mils of finished tincture. Details as in making tincture of aloes.

Dose.—2 mils (30 minims).

TINCTURA HYDRASTIS—Tincture of Hydrastis

(Tr. Hydrast.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 60 powder with the menstruum—666 mils alcohol; 333 mils water; macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—The pharmacopœial assay of this tincture will be given in Chapter LV. It should contain from $^{36}/_{100}$ to $^{44}/_{100}$ of 1 per cent. of ether-soluble alkaloids.

Dose.—4 mils (1 fluidrachm).

TINCTURA HYOSCYAMI—Tincture of Hyoscyamus

(Tr. Hyoscy.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 60 powder with the menstruum—diluted alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—The pharmacopœial assay of this tincture will be given in Chapter LV. It should contain from $^{55}/_{10000}$ to $^{75}/_{10000}$ of 1 per cent. of mydriatic alkaloids.

Dose.—2 mils (30 minims).

TINCTURA IODI—Tincture of Iodine

This important official will be discussed under Iodine (p. 379).

TINCTURA KINO—Tincture of Kino

(Tr. Kino)

Condensed Recipe.

Pour boiling water on 100 Gm. of kino and then heat on a water-bath for one hour. Then add enough water to make 500 mils and also 500 mils of alcohol. Macerate mixture, decant and strain. For details, see U.S.P., p. 458.

Remarks.—The tincture of kino of the former pharmacopœias had to be kept in small well-stoppered and completely filled bottles; else it gelatinized. It has been found that this gelatinization was due to an enzyme, which can be destroyed by heat, hence the direction in the present recipe to heat the drug with water on a water-bath for an hour. The infusion (or decoction) thus prepared is then mixed with alcohol.

Dose.—4 mils (1 fluidrachm).

TINCTURA LACTUCARII—Tincture of Lactucarium

(Tr. Lactucar.)

Condensed Recipe.

Ingredients.—Lactucarium, 500 Gm.; glycerin, 250 mils; alcohol, purified petroleum benzin, diluted alcohol, water, of these enough to make 1 liter.

Manipulation.—Extract the lactucarium with the benzin by maceration, filter off the benzin, dry the residual lactucarium in a current of air, then percolate it to exhaustion first with the glycerin mixed with 250 mils of water and 500 mils of alcohol and latterly with diluted alcohol. Reserve the first 750 mils of percolate, evaporate the rest to 250 mils and mix it with the reserved portion. Lastly filter and wash filter with enough diluted alcohol to make 1 liter.

Remarks.—Tincture of lactucarium is interesting in that the lactucarium is first washed with petroleum benzin to remove the rubber-like, inert substance it contains. Be sure that the benzin used is of pharmacopœial purity, as commercial benzin is too impure for pharmacopœial purposes. (See p. 577.)

Note that the drug is not easily exhausted with the menstruum employed, and that in making 1000 mils, the first 750 mils of percolate is reserved and the rest of the percolate evaporated, similar to making fluidextracts.

Dose.—2 mils (30 minims).

TINCTURA LAVANDULÆ COMPOSITA—Compound Tincture of Lavender

(Tr. Lavand. Co.)

Condensed Recipe.

Macerate 20 Gm. Saigon cinnamon; 5 Gm. clove; 10 Gm. myristica and 10 Gm. red Saunders, with the menstruum—alcohol, 750 mils; oil of lavender, 8 mils; oil of rosemary, 2 mils; water, 250 mils. Complete the preparation with a menstruum consisting of alcohol 750 mils; water 250 mils. Details as in making tincture of aloes.

Remarks.—This tincture is sometimes called "red lavender," because of its brilliant color, due to the red saunders, it contains. It is reputed good in "heart trouble," although, in truth, its only value is to relieve flatulence.

Dose.—2 mils (30 minims).

TINCTURA LIMONIS CORTICIS—Tincture of Lemon Peel

(Tr. Limon. Cort.)

Condensed Recipe.

This is a 50 per cent. alcoholic extract of fresh lemon peel, made exactly as tincture of sweet orange peel.

Remarks.—Tincture of lemon peel replaces *spirit of lemon* of the pharmacopœia of 1890. It is used entirely as a flavor, hence no dose is given.

TINCTURA LOBELIÆ—Tincture of Lobelia

(Tr. Lobel.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 50 powder with the menstruum—diluted alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Dose.—1 mil (15 minims).

TINCTURA MOSCHI—Tincture of Musk

(Tr. Mosch.)

Condensed Recipe.

Ingredients.—Musk, 5 Gm.; alcohol 45 mils; water, 45 mils; diluted alcohol enough to make 100 mils.

Manipulation.—Triturate the musk with the water to a smooth paste. Bottle this macerate twenty-four hours without and six days with the alcohol. Filter mixture and wash filter with enough diluted alcohol to make 100 mils.

Remarks.—As seen in the recipe given above, this tincture is made by rubbing musk with water, adding alcohol, filtering, and washing residue with diluted alcohol.

It contains 5 per cent. of musk and should be prepared with the utmost care, for when it is required, a fine quality is absolutely essential, it being used chiefly as a stimulant in extreme cases of pneumonia.

Dose.—4 mils (1 fluidrachm).

TINCTURA MYRRHÆ—Tincture of Myrrh
(Tr. Myrrh)

Condensed Recipe.
Macerate 200 Gm. of the drug in a moderately coarse powder with enough menstruum—alcohol (U.S.P.)—to make 1000 mils. Details as in making tincture of aloes.

Remarks.—Myrrh (see p. 777) contains a larger percentage of gummy matter than asafetida, and this gum, which does not dissolve in the strong alcoholic menstruum and which is left on the filter, after making the tincture, has been suggested as a source of label mucilage.

The tincture is used considerably in mouth-washes and is not often given internally.

Dose.—1 mil (15 minims).

TINCTURA NUCIS VOMICÆ—Tincture of Nux Vomica
(Tr. Nux Vom.)

Condensed Recipe.
Moisten 100 Gm. of the drug in a No. 40 powder, with the menstruum—alcohol, 750 mils; water, 250 mils; macerate and then percolate (not faster than 10 drops a minute) to 1000 mils. Details as in making tincture of aconite.

For Assay, see Chapter LV.

Remarks.—In the above recipe, the pharmacopœia goes back to the original process of preparing the tincture from the drug after two decades of preparing it from the solid extract. The Brussels Conference (p. 19) dubbed the preparation *strychni tinctura*, P.I.

Dose.—0.5 mil (8 minims).

TINCTURA OPII—Tincture of Opium
(Tr. Opii—Laudanum—Opii tinctura P.I.)

One hundred mils of Tincture of Opium yields not less than 0.95 Gm. nor more than 1.05 Gm. of anhydrous morphine.

Condensed Recipe.
Ingredients.—Granulated opium, 100 Gm.; alcohol; water; diluted alcohol, enough to make 1 liter.

Manipulation.—Four hundred mils of boiling water are poured upon the opium and the mixture is macerated for twelve hours. Four hundred mils of alcohol are then added and the mixture is macerated for forty-eight hours, after which it is transferred to a percolator. After the liquid has drained off, the percolation is continued until 950 mils of tincture are obtained. This is then assayed and treated as in making tincture of aconite. (For details, see U.S.P., p. 462.

Remarks.—Note that this tincture—called *laudanum, tinctura thebaica*, etc.—is directed to be made from granulated opium, not from the gum, as some druggists prepare it. Bear in mind that gum opium is weaker than granulated opium and that a preparation made from it will be deficient in strength unless a proportionally large amount is employed.

It will be noted that the recipe just given directs that the opium be macerated with hot water during twelve hours, after which there is added to the then cold mixture a volume of alcohol equal to the volume of water originally used. The mixture is then transferred to a percolator; diluted alcohol being used as the final menstruum.

Dose.—0.5 mils (8 minims).

TINCTURA OPII CAMPHORATA—Camphorated Tincture of Opium
(Tr. Opii Camph.)

Condensed Recipe.
Macerate 4 Gm. powdered opium; 4 Gm. benzoic acid; 4 Gm. camphor and 4 mils of oil of anise with the menstruum—glycerin, 40 mils; diluted alcohol, 950 mils. Complete the preparation with diluted alcohol. Details as in making tincture of aloes.

Remarks.—This popular official is commonly called *paregoric,* the latter word meaning "soothing," the tincture being originally called "elixir paragoricus," soothing elixir. The synonym given it by the Brussels Conference was *opii tinctura benzoici* P.I. Note that it contains 0.4 of 1 per cent. of opium and that it is a constituent of brown mixture (p. 257).

Dose.—4 mils (1 fluidrachm).

TINCTURA OPII DEODORATI—Tincture of Deodorized Opium

(Tr. Opii Deod.)

One hundred mils of Tincture of Deodorized Opium yields not less than 0.95 Gm. nor more than 1.05 Gm. of anhydrous morphine.

Condensed Recipe.

Ingredients.—Granulated opium, 100 Gm.; alcohol, 200 mils; water, enough to make 1000 mils. Purified petroleum benzin used for "shaking out."

Manipulation.—Upon the opium, 500 mils of boiling water are poured and after twenty-four hours maceration, the mixture is percolated with water to exhaustion. The percolate is concentrated on a water-bath to 150 mils and after cooling is shaken out with two portions of benzin. From the aqueous liquid so treated the odor of benzin is removed by spontaneous evaporation and latterly by the heat of a water-bath. It is then diluted with more water, the alcohol is added and lastly enough water is added to make 950 mils of liquid. A part of this is assayed and the rest of the process is as in making tincture of aconite. For details, see U.S.P., p. 463.

Remarks.—This tincture represents an evaporated aqueous percolate of opium, deprived of its odor and of its noxious narcotic principle—narcotine—by shaking with purified petroleum benzin, diluted with water, and then mixed with enough alcohol (200 mils to 1000 mils of finished tincture) to preserve it. The finished product must represent 10 per cent. of official opium and 0.95 per cent. to 1.05 per cent. morphine. The pharmacopœial assay will be found in Chapter LV.

This product was originally introduced as a proprietary, and because freed from narcotine, was called *denarcotized tincture of opium.* It is supposed to have less unpleasant after-effects than has laudanum.

Dose.—0.5 mil (8 minims).

TINCTURA PHYSOSTIGMATIS—Tincture of Physostigma

(Tr. Physostig.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 50 powder with the menstruum—alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—The pharmacopœial assay of this tincture will be found in Chapter LV. It should contain from $^{13}/_{1000}$ to $^{17}/_{1000}$ of 1 per cent. of the alkaloids of physostigma.

Dose.—1 mil (15 minims).

TINCTURA PYRETHRI—Tincture of Pyrethrum

(Tr. Pyreth.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 50 powder with the menstruum—alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel. Since used almost entirely externally, no dose is given by the pharmacopœia.

TINCTURA QUASSIÆ—Tincture of Quassia

(Tr. Quass.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 50 powder with the menstruum—alcohol, 333 mils; water, 666 mils; macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Remarks.—The recipe is interesting because of the small amount of alcohol used in the menstruum.

Dose.—2 mils (30 minims).

TINCTURA RHEI—Tincture of Rhubarb
(Tr. Rhei)

Condensed Recipe.

Moisten 200 Gm. rhubarb and 30 Gm. cardamom seed, each in a No. 40 powder, with the menstruum—alcohol, 500 mils; water, 400 mils; glycerin, 100 mils; macerate and then percolate to 1000 mils, using diluted alcohol as the final menstruum. Details as in making tincture of cinchona.

Remarks.—Note that this tincture contains cardamom seed besides rhubarb; one of the few cases where a preparation containing more than one drug is not pharmacopœially termed "compound."

Dose.—4 mils (1 fluidrachm).

TINCTURA RHEI AROMATICA—Aromatic Tincture of Rhubarb
(Tr. Rhei Arom.)

Condensed Recipe.

Moisten 200 Gm. rhubarb, 40 Gm. Saigon cinnamon, 40 Gm. cloves, and 20 Gm. nutmeg, each in a No. 40 powder, with the menstruum—alcohol, 500 mils; water, 400 mils; glycerin, 100 mils; macerate and then percolate to 1000 mils, using diluted alcohol as the final menstruum. Details as in making tincture of cinchona.

Remarks.—Note the aromatic constituents of this tincture, which is rarely prescribed, and which is official chiefly because used in making the official aromatic syrup of rhubarb (p. 199).

Dose.—2 mils (30 minims).

TINCTURA SANGUINARIÆ—Tincture of Sanguinaria
(Tr. Sanguin.—Tincture of Bloodroot)

Condensed Recipe.

Ingredients.—Sanguinaria, 100 Gm.; hydrochloric acid, 10 mils; alcohol; water to make 1 liter.

Manipulation.—Moisten the drug with a mixture of the acid, 18 mils of alcohol and 12 mils of water. Macerate six hours before and twenty-four hours after packing. Percolate with the menstruum—alcohol, 600 mils; water, 400 mils—until a liter of tincture is obtained. For details, see U.S.P., p. 466.

Remarks.—This is the only official tincture extracted with menstruum containing acid, and it is worth noting that 1000 mils of finished tincture contains but 10 mils of hydrochloric acid; that all this is mixed with the menstruum used in moistening the drug; and that all the menstruum used in percolation is hydro-alcoholic.

Dose.—1 mil (15 minims).

TINCTURA SCILLÆ—Tincture of Squill
(Tr. Scill.)

If assayed biologically the minimum lethal dose should not be greater than 0.006 mil of Tincture or the equivalent in Tincture of 0.0000005 Gm. of ouabain, for each gramme of body weight of frog.

Condensed Recipe.

Squill (100 Gm.) is moistened with the menstruum—alcohol, 3 volumes; water, 1 volume—is macerated twenty-four hours before and twenty-four hours after packing and is then percolated until 1 liter of tincture is obtained. For details, see U.S.P., p. 466.

Remarks.—It will be noted that in making this tincture, the drug after moistening and maceration, is transferred to a percolator and is percolated without packing. If it were packed with ordinary pressure, the percolate would not drop. Note that the preparation may be biologically assayed.

Dose.—1 mil (15 minims).

TINCTURA STRAMONII—Tincture of Stramonium

(Tr. Stramon.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 60 powder with the menstruum—diluted alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of aconite.

Remarks.—The pharmacopœial assay of this tincture will be found in Chapter LV. It should contain $^{225}/_{10000}$ to $^{275}/_{10000}$ of 1 per cent. of mydriatic alkaloids.

Dose.—0.5 mil (8 minims).

TINCTURA STROPHANTHI—Tincture of Strophanthus

(Tr. Strophanth.—Strophanthi tinctura P.I.)

If assayed biologically the minimum lethal dose should not be greater than 0.00006 mil of Tincture or the equivalent in Tincture of 0.0000005 Gm. of ouabain for each gramme of body weight of frog.

Condensed Recipe.

Strophanthus (100 Gm.) is freed from fat by percolating with purified petroleum benzin. It is dried, moistened with alcohol, macerated six hours before and forty-eight hours after packing and is then percolated with alcohol until 1 liter of tincture is obtained. For details, see U.S.P., p. 467.

Remarks.—The recipe for this preparation given in the present pharmacopœia is different from that provided in U.S.P. VIII. Now the drug is defatted by percolation with purified petroleum benzin, prior to percolation with the regular menstruum;—alcohol. Note that the tincture may be assayed biologically (p. See Part V).

Dose.—0.5 mil (8 minims).

TINCTURA TOLUTANA—Tincture of Tolu

(Tr. Tolu.)

Condensed Recipe.

Macerate 200 Gm. balsam of tolu with enough alcohol to make 1000 mils. Details as in making tincture of aloes.

Remarks.—Unlike benzoin and other resinous drugs from which tinctures are prepared, tolu is practically completely soluble in alcohol; hence the manufacture might be considered as one of solution rather than as one of maceration. The tincture is used in making the official *Syrup of Tolu* (p. 200).

Dose.—2 mils (30 minims).

TINCTURA VALERIANÆ—Tincture of Valerian

(Tr. Valer.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 40 powder with the menstruum—alcohol, 750 mils; water, 250 mils; macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Dose.—4 mils (1 fluidrachm).

TINCTURA VALERIANÆ AMMONIATA—Ammoniated Tincture of Valerian (Tr. Valer Ammon.)

Condensed Recipe.

Identical with that for tincture of valerian, save in the menstruum. Aromatic spirit of ammonia is employed.

Remarks.—Note that this is one of the two official tinctures made with aromatic spirit of ammonia as the menstruum, the other being ammoniated tincture of guaiac.

Dose.—2 mils (30 minims).

TINCTURA VERATRI VIRIDIS—Tincture of Veratrum Viride
(Tr. Verat Vir.)

Condensed Recipe.

Moisten 100 Gm. of the drug in a No. 60 powder with the menstruum—alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Remarks.—While U.S.P. VIII directed a tincture of veratrum made either from *Veratrum album* or from *Veratrum viride*, the present pharmacopœia recognizes only the latter drug—green hellebore—and so the preparation now under consideration is a tincture of veratrum viride. It is a 10 per cent. tincture; quite different from the tincture of the pharmacopœia of 1890 which was a 40 per cent. product. The latter closely simulated *Norwood's tincture of veratrum*, formerly largely prescribed.

Dose.—0.5 mil (8 minims).

TINCTURA ZINGIBERIS—Tincture of Ginger
(Tr. Zingib.)

Condensed Recipe.

Moisten 200 Gm. of the drug in a No. 30 powder with the menstruum—alcohol (U.S.P.); macerate and then percolate to 1000 mils. Details as in making tincture of bitter orange peel.

Remarks.—This is the well-known *essence of ginger*. It represents 20 per cent. of the drug, and is made with strong alcohol. When mixed with water, it forms a milky mixture, due to the separation of the resin. The so-called water-soluble ginger is the tincture rubbed with magnesium carbonate and enough water to precipitate much of the resin. Note that the present pharmacopœia gives specifications for a properly prepared tincture of ginger, including amount of residue and a test for the presence of capsicum. (See U.S.P., p. 469.)

Dose.—2 mils. (30 minims).

Tinctura Ipecacuanhæ et Opii (U.S.P. VIII; N.F. IV) is commonly known as *tincture of Dover's powder*. It is made by evaporating 1000 mils of tincture of deodorized opium to a bulk less than 900 mils; in order that 100 mils of fluidextract of ipecac may be added along with enough diluted alcohol to bring the total volume to 1 liter. Thus the finished preparation represents 10 per cent. of opium and 10 per cent. of ipecac.

Tinctura Quillajæ (U.S.P. VIII; N.F. IV) is an aqueous decoction of soap bark with enough alcohol (350 mils to the 1000) added to preserve it. The preparation is used as an emulsifying agent (see p. 260), but it should never be used for that purpose except under direct orders of a physician, since the saponin of the bark is distinctly poisonous. It is used as a "gum foam" at the soda fountain, and this use is also objectionable and is prohibited in some states.

Tinctura Vanillæ (U.S.P. VIII; N.F. IV) is made by macerating cut vanilla beans in alcohol for two days; filtering off the alcohol, mixing the dried beans with sugar and grinding to a uniform powder which is then percolated with the alcoholic filtrate to which an equal volume of water has been added. The resulting product represents 10 per cent. of vanilla beans and contains 20 per cent. of sugar in what is approximately diluted alcohol and is a fine grade of the flavoring *essence of vanilla*. What is commonly sold under this name, however, is a concoction of various inferior flavors, such as coumarin and possibly some vanillin. Another point in connection with the manufacture of the tincture of vanilla is that, in order to secure a really fine tincture of vanilla, it is essential to use a good quality of vanilla bean. The inferior Tahiti beans can never yield anything but a poor product.

Tincturæ Æthereæ (N.F.) represent a class of tinctures in which the menstruum employed consists of alcohol and ether. The National Formulary gives a general formula for such preparations directing that the menstruum consist of 1 volume of ether and 2 volumes of alcohol and that the finished tincture represents 10 per cent. of the drug used. Ethereal tincture of valerian enjoys some vogue.

Tincturæ Herbarum Recentium (U.S.P. VIII) or *Tincturæ medicamentorum recentium*, N.F. IV, are a line of preparations made by macerating 500 Gm. of the fresh herb or drug with 1000 mils of alcohol for fourteen days after which the mixture is expressed and the expressed liquid is strained. They resemble the *juices* (Succi) of the British Pharmacopœia and are rarely used in this country.

TINCTURES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Tinctura aloes et myrrhæ.	Tincture of aloes and myrrh.	Aloes, myrrh and glycyrrhiza of each 100 Gm. Menstruum, alcohol, 750 mils; water, 250 mils.	Made by maceration. Was official in U.S.P. VIII. *Dose.*—2 mils (30 minims).
Tinctura amara.	Stomach drops, etc.	Gentian, centaury and bitter orange peel, of each 60 Gm.; zedoary. Menstruum, alcohol, 2 volumes; water 1 volume.	Made by percolation. *Dose.*—2 mils (30 minims).
Tinctura antiperiodica.	Warburg's tincture.	Rhubarb; angelica fruit; elecampane; saffron; fennel; gentian; zedoary; cubeb, myrrh; camphor; agaric; pepper; Saigon cinnamon; ginger; quinine bisulphate; extract of aloes. Menstruum, alcohol, 3 volumes; water, 2 volumes.	Made by percolation of the drugs; the quinine salt and the extract of aloes being dissolved in the tincture. *Dose.*—4 to 15 mils (1 to 4 fluidrachms).
Tinctura antiperiodica sine aloe.	Warburg's tincture, without aloes.	The foregoing, with the extract of aloes omitted.	
Tinctura aromatica.	Aromatic tincture.	Saigon cinnamon; jamaica ginger; galangal; clove; cardamom seed. Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation. *Dose.*—2 mils (30 minims).
Tinctura bryoniæ.	Tincture of bryonia.	Bryonia, 100 Gm.; alcohol.	Made by percolation *Dose.*—4 mils (1 fluidrachm).
Tinctura cacti grandiflori.	Tincture of night blooming cereus.	Cactus grandiflorus, 500 Gm.; alcohol.	Made by maceration of the fresh flowers with subsequent expression. *Dose.*—1 mil (15 minims).
Tinctura calendulæ.	Tincture of marigold.	Calendula, 200 Gm.; alcohol.	Made by percolation. Was official in U.S.P. VIII. No dose mentioned.
Tinctura capsici et myrrhæ.	Hot drops; number six.	Capsicum, 30 Gm.; myrrh, 120 Gm. Menstruum, alcohol, 9 volumes; water, 1 volume.	Made by percolation of the drugs mixed with sand. *Dose.*—2 mils (30 minims).
Tinctura caramelis.	Tincture of caramel.	Caramel, 100 Gm.; water; alcohol.	Made by solution and filtration. Used as color.
Tinctura cimicifugæ.	Tincture of cimicifuga.	Cimicifuga, 200 Gm.; alcohol.	Made by percolation. Was official in U.S.P. VIII. *Dose.*—4 mils (1 fluidrachm).
Tinctura cocculi indici.	Tincture of fish berries.	Cocculus indica, 100 Gm.; diluted alcohol.	Made by percolation. Used as vermin killer.
Tinctura croci.	Tincture of saffron.	Saffron, 100 Gm.; diluted alcohol.	Made by percolation; no dose mentioned.
Tinctura cubebæ.	Tincture of cubeb.	Cubeb, 200 Gm.; alcohol.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura delphinii.	Tincture of larkspur.	Larkspur seed, 100 Gm.; alcohol.	Made by percolation. Used as vermin killer.
Tinctura ergotæ ammoniata	Ammoniated tincture of ergot.	Ergot, 250 Gm.; ammonia water, 100 mils; alcohol; water.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura ferri chloridi ætherea.	Bestuscheff's tincture; Lamotte's drops.	Solution of ferric chloride, 60 mils; ether; alcohol.	See p. 511. *Dose.*—2 mils (30 minims).

TINCTURES OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils.)	Remarks
Tinctura ferri citrochloridi.	Tasteless tincture of iron.	Solution of ferric chloride, 350 mils; sodium citrate, 500 Gm.; alcohol; water.	See p. 511. *Dose.*—0.5 mil (8 minims).
Tinctura ferri pomata.	Tincture of ferrated extract of apples.	Ferrated extract of apples, 100 Gm.; alcohol; cinnamon water.	See p. 614. *Dose.*—4 mils (1 fluidrachm).
Tinctura gallæ.	Tincture of nutgall.	Nutgall, 200 Gm. Menstruum, glycerin 100 mils; alcohol 900 mils.	Made by maceration. Replaces the tincture of U.S.P. VIII. *Dose.*—4 mils (1 fluidrachm).
Tinctura guaiaci compositus.	Dewee's tincture of guaiac.	Guaiac, 125 Gm.; potassium carbonate; pimenta; alcohol; water. Pumice as clarifier.	Made by trituration and filtration. *Dose.*—4 mils (1 fluidrachm).
Tinctura humuli	Tincture of hops.	Hops, 200 Gm.; diluted alcohol.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura ignatiæ.	Tincture of ignatia.	Ignatia, 100 Gm. Menstruum, alcohol, 8 volumes; water, 1 volume.	Made by percolation. Must assay $^{19}/_{100}$ to $^{23}/_{100}$ of 1 per cent. of alkaloids. *Dose.*—0.6 mil (10 minims).
Tinctura iodi fortior.	Churchill's tincture of iodine.	Iodine, 165 Gm.; potassium iodide, 33 Gm.; water, alcohol.	Over twice as strong as the U.S.P. tincture.
Tinctura iodi decolorata.	Decolorized tincture of iodine.	Iodine, 83 Gm.; sodium thiosulphate; stronger ammonia water; water; alcohol.	See p. 378.
Tinctura ipecacuanhæ et opii.	Tincture of Dover's powder.	....	See p. 234.
Tinctura jalapæ.	Tincture of jalap.	Jalap, 200 Gm. Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura jalapæ composita.	Compound tincture of jalap.	Jalap, 125 Gm.; resin of scammony, 30 Gm., Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation of the drugs mixed with sand. *Dose.*—4 mils (1 fluidrachm).
Tinctura kino et opii composita.	Compound tincture of kino.	Tincture of kino, 200 mils; tincture of opium, 100 mils; spirit of camphor; oil of clove; aromatic spirit of ammonia; diluted alcohol; cochineal as color.	Made by admixture and filtration. *Dose.*—4 mils (1 fluidrachm).
Tinctura krameriæ.	Tincture of krameria.	Krameria, 200 Gm.; diluted alcohol.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura opii crocata.	Sydenham's laudanum.	Granulated opium, 100 Gm.; saffron; Saigon cinnamon; clove; diluted alcohol.	Made by percolation of the drugs mixed with sand. Must assay 0.95 to 1.05 per cent. of morphine. *Dose.*—0.6 mil (10 minims).
Tinctura paracoto.	[Tinctura coto, N.F. III].	Paracoto, 125 Gm.; alcohol.	Made by percolation. *Dose.*—2 mils (30 minims).
Tinctura passifloræ.	Tincture of passion flower.	Passion flower, 200 Gm.; diluted alcohol.	Made by percolation. *Dose.*—0.6 mil (10 minims).
Tinctura pectoralis.	Bateman's pectoral drops.	Tincture of opium, 42 mils; compound tincture of gambir; spirit of camphor; oil of anise; diluted alcohol. Caramel as color.	Made by admixture and filtration. *Dose.*—(for infants) 0.6 mil (10 minims).

TINCTURES OF THE NATIONAL FORMULARY—(*Continued*)

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Tinctura persionis.	Tincture of cudbear.	Cudbear, 100 Gm. Menstruum, alcohol, 3 volumes; water, 1 volume.	Made by percolation. Used as a coloring agent.
Tinctura persionis composita.	Compound tincture of cudbear.	Cudbear, 15 Gm.; caramel, 100 Gm.; alcohol; water.	Made by maceration and admixture. Used as a coloring agent.
Tinctura pimpinellæ.	Tincture of pimpinella.	Pimpinella root, 200 Gm. Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura pulsatillæ.	Tincture of pulsatilla.	Pulsatilla, 100 Gm. Menstruum, alcohol, 3 volumes; water, 1 volume.	Made by percolation. *Dose.*—2 mils (30 minims).
Tinctura quillajæ.	Tincture of soap bark.	....	See p. 234.
Tinctura rhei aquosa.	Aqueous tincture of rhubarb.	Rhubarb, 100 Gm.; potassium carbonate; cinnamon water; alcohol, 110 mils; water.	Made by maceration of the rhubarb and the carbonate with water followed by boiling, straining and admixture of the other ingredients. *Dose.*—4 mils (1 fluidrachm).
Tinctura rhei dulcis.	Sweet tincture of rhubarb.	Rhubarb, 100 Gm.; glycyrrhiza; anise; cardamom seed. Menstruum, glycerin, alcohol and water; followed by diluted alcohol.	Made by percolation. *Dose.*—2 mils (30 minims).
Tinctura rhei et gentianæ.	Tincture of rhubarb and gentian.	Rhubarb, 70 Gm.; gentian; diluted alcohol.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura sabal et santali.	Tincture of Saw palmetto and santal.	Sabal, 200 Gm.; sandal wood. Menstruum, alcohol, 4 volumes; water, 1 volume.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura serpentariæ.	Tincture of serpentaria.	Serpentaria, 200 Gm. Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation. Was official in U.S.P. VIII. *Dose.*—4 mils (1 fluidrachm).
Tinctura sumbul.	Tincture of sumbul.	Sumbul, 100 Gm. Menstruum, alcohol, 2 volumes; water, 1 volumes, 0.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura vanillæ.	Tincture of vanilla.	....	See p. 234.
Tinctura viburni opuli composita.	Compound tincture of viburnum opulus.	Viburnum opulus; dioscorea; scutellaria; clove; Saigon cinnamon. Menstruum, glycerin, alcohol, water; then alcohol, 3 volumes; water, 1 volume.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tinctura zedoariæ amara.	Compound tincture of zedoary.	Zedoary; aloes; rhubarb; gentian; agaric; saffron; glycerin. Menstruum, alcohol, 2 volumes; water, 1 volume.	Made by percolation. *Dose.*—4 mils (1 fluidrachm).
Tincturæ ethereæ	Ethereal tinctures.	....	See p. 234.
Tincturæ medicamentorum recentium.	Tinctures of fresh drugs.	....	See p. 234.

THE DOSES OF OFFICIAL TINCTURES

0.1 mil (1½ minims)	Tinctures of cantharides, iodine.
0.25 mil (4 minims)	Tincture of gelsemium.
0.3 mil (5 minims)	Tincture of aconite.
0.5 mil (8 minims)	Tinctures of capsicum, digitalis, ferric chloride, nux vomica, opium, deodorized opium, stramonium, strophanthus and veratrum viride.
0.75 mil (12 minims)	Belladonna leaves and cannabis.
1.0 mil (15 minims)	Tinctures of arnica, asafetida, benzoin, lobelia, myrrh, physostigma, sanguinaria and squill.
2.0 mils (30 minims)	Tinctures of aloes, benzoin compound, cardamon seed, cinnamon, colchicum seed, ginger, guaiac ammoniated, hyoscyamus, lactucarium, lavender compound, quassia, rhubarb aromatic, tolu, and valerian ammoniated.
4.0 mils (1 fluidrachm)	Tinctures of bitter orange peel, calumba, cardamon compound, cinchona, cinchona compound, gambir compound, gentian compound, guaiac, hydrastis, kino, musk, opium camphorated, rhubarb, sweet orange peel and valerian.
No doses given.	Tinctures of lemon peel and pyrethrum.

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CHAPTER XV

FLUIDEXTRACTS, WINES, OLEORESINS, AND VINEGARS

FLUIDEXTRACTS

FLUIDEXTRACTS are alcoholic liquid preparations made by percolation, representing in each milliliter the activity of one gramme of drug; in other words, they are 100 per cent. tinctures.

The fluidextracts of the present pharmacopœia, of the strength of one gramme to the milliliter, are 5 per cent. weaker than those directed by the pharmacopœia of 1870, which represented a troy ounce of drug to the fluidounce. The difference in these strengths is apparent when we appreciate the fact that while the gramme of water is always of the same weight as the milliliter, the troy ounce of water will weigh 480 grains against the 454.6 grains, which is the weight of the fluidounce of water.

Fluidextracts can be considered in the light of concentrated tinctures, and many official drugs have both the tincture and the fluidextract recognized by the pharmacopœia. The advantages which the fluidextracts possess over tinctures and other preparations are: 1. That they possess a definite strength of 100 per cent., the same as that of the product from which derived. In that way the physician, knowing the dose of the drug, has no difficulty in knowing the dose of a fluidextract. 2. Fluidextracts are concentrated, a very small quantity of fluidextract sufficing, where a much larger quantity, sometimes ten times the amount, of a tincture will be needed. 3. Fluidextracts are permanent. Being made with alcoholic menstrua, they keep perfectly, and, in fact, frequently become better as they age.

History.—The first reference to fluidextracts that has been found is in a paper by Ellis (1835) in which it is stated that they "are preparations that have been popular in England within a few years past." The United States Pharmacopœia of 1850 recognized seven so-called fluidextracts and of these but one was a fluidextract in the modern sense of the term. Of the others, four were concentrated syrups and two were oleoresins. In the pharmacopœia of 1860 twenty-five fluidextracts were recognized, and of these, fifteen were fluidextracts in the modern sense of the term.

Manufacture of Fluidextracts.—Five general processes have been suggested for the manufacture of fluidextracts: (*a*) percolation with partial evaporation; (*b*) fractional or divided percolation; (*c*) repercolation; (*d*) percolation with incomplete exhaustion; (*e*) maceration with hydraulic pressure. In addition, in special cases, the fluidextract is made by making an infusion or decoction of the drug and adding to this enough alcohol to keep the preparation from spoiling. The first, second and sixth method are described at some length in the general formula for fluidextracts printed in the present pharmacopœia. (See U.S.P., pp. 173 to 176.)

Type Processes A and B, given in the pharmacopœial general formula, are both methods of percolation with partial evaporation, the only difference being whether the menstruum contains glycerin or not. In Process A, the drug is moistened with the required quantity of menstruum and macerated first outside then within, the percolator for a certain length of time, and then percolated with the menstruum until exhausted.

It is practically impossible, by the ordinary process of percolation, to exhaust 100 Gm. of drug with the first 100 mils of percolate; in most cases 100 Gm. are not exhausted until about 500 mils of percolate have been obtained. Accordingly, in making fluidextracts we percolate the drug until it is exhausted, and instead of evaporating the entire percolate down to 100 mils, we reserve the first 85 mils of percolate, subjecting to the heat of evaporation only the balance of percolate.

The first portion of the percolate is put to one side and labeled "reserved portion." The rest of the percolate, called "weak percolate," is then placed in an appropriate distilling apparatus in order to recover the alcohol, and when the alcohol is distilled, the residue is evaporated to a soft extract on a water-bath. This soft extract is then dissolved in the reserved portion, and enough menstruum is added to bring the fluidextract up to the number of milliliters equal to the number of grammes of the drug with which we started. Of the details of this process but two salient points need be mentioned. It will be noticed that we spare the first 85 per cent. of percolate from the heat to which we subject the remainder of the percolate. This is because it is supposed that this 85 per cent. of percolate contains the active principles of at least 85 per cent. of the drug, and since it is without question that even the heat of the water-bath may possibly modify some of the delicate constituents of the drug, it has been deemed advisable to expose the smallest possible quantity of the soluble part of the drug to such temperature. A second point is that we evaporate the weak percolate to a soft extract instead of merely to a point where it, plus the reserve portion, would measure the number of mils of fluid equal to the number of grammes of drug with which we started out. The reason for this is because the liquid part of such a residue consists wholly of water, and that there would be danger that adding the liquid to the reserve portion would cause a precipitation of some of the constituents of the reserved portion.

This process is not a satisfactory one either for the manufacturer or for the retailer. For the retailer, it is a tedious operation, requiring a large amount of time for evaporation of the reserve portion, and especially when the menstruum is a diluted alcohol. The second disadvantage of the process is the use of heat, which tends to dissociate some of the plant principles.

It will be noticed that the general formula specifies that in evaporation, the weak percolate must not be heated above 60°C. As the formula directs that the alcohol be "recovered" it is assumed that distillation be employed and this operation can occur at 60°C., only when carried on in a vacuum pan; a piece of apparatus that is too expensive to be used by the retail pharmacist.

In Type Process B, the menstruum from which the reserved portion is to be prepared contains glycerin or acid, while that from which the reserved portion is prepared is to be free from these substances. The reason for this provision is to prevent the evaporated reserved portion from adding to the finished fluidextract an undue amount of either glycerin or acid which would not volatilize along with the alcohol and water.

Type Process C of the pharmacopœia is devised to permit the preparation of a fluidextract by percolation without evaporation. It is a modification of the well-known method of re-percolation and will be explained with the latter below.

Type Process D directs the preparation of an infusion or decoction of the drug and the addition to it, when sufficiently concentrated, of enough alcohol to preserve it. The process is employed in making the official fluidextracts of cascara sagrada; cascara sagrada, aromatic; frangula and triticum; and in somewhat modified form in fluidextract of glycyrrhiza.

Repercolation is a process devised by Dr. E. R. Squibb as a means of doing away with the use of heat in the preparation of fluidextracts. The manipulation can be expressed as follows:

Suppose we want to make 1000 mils fluidextract of gentian; we take 1000 Gm. drug, and the first thing we do with it is to divide it into four portions of 250 Gm. each. The first 250 Gm. we moisten with the menstruum, pack, macerate, and percolate, just as in the regular official process, with the sole exception that the percolate, as it drops, is collected into several portions; the first 200 mils—dark, heavy, and concentrated—being set aside as finished fluidextract, and the next portions of 250 mils each put into bottles and labeled respectively "weak percolate No. 1," "weak percolate No. 2," "weak percolate No. 3," and so on until exhaustion. The writer's personal experience showed that, on an average, 250 Gm. drug is not completely exhausted until 1250 to 1500 mils of percolate have dropped, and it was his rule to use a 500-mil bottle for weak percolate No. 4, and to let the last percolate drop therein until the drug was completely exhausted.

As the result of our first percolation we have, from 250 Gm. gentian:

Fluidextract	200 mils
Weak percolate No. 1	250 mils
Weak percolate No. 2	250 mils
Weak percolate No. 3	250 mils
Weak percolate No. 4 (say)	350 mils

The first 200 mils called "fluidextract" above is supposed to contain the active principles of 200 Gm. drug, the remaining active principles of the drug will be found in the 1100 mils of weak percolates Nos. 1, 2, 3, and 4 and chiefly in percolates No. 1 and 2. Now we are ready to begin with the second batch of 250 Gm. of ground gentian. We moisten it, not with official menstruum, but with weak percolate No. 1 of the previous operation. Then we pack and macerate, then pour in weak percolate No. 2, and after it has soaked in, we pour on weak percolate No. 3, and as that too sinks down as the liquid drops below, we pour on weak percolate No. 4. When that has gone through, we begin to employ the official menstruum. In the meanwhile the liquid dropping from the percolator has been collected in several portions. The first 250 mils has been set aside as finished fluidextract. Note that this time we do not set aside the first 200 mils as finished fluidextract, as we did in the previous case, but 250 mils; for we began percolation this time, not with official menstruum, but with those percolates from the first batch of drug, containing the active principles of about 50 Gm. of said drug. The first 250 mils from the second batch of drug was assumed to contain the active principles of 250 Gm. of drug and is therefore set aside as finished fluidextract.

By this time the bottles that had contained weak percolates No. 1 and 2 are empty, and as the next 250 mils percolate drops, it is poured into bottle No. 1; the next batch into bottle No. 2, and so on until exhaustion, when we will have in the four original bottles weak percolates No. 1, 2, 3, and 4.

The percolation of batches No. 3 and 4, 250 Gm. each, of gentian, will be a repetition of the handling of batch No. 2. In both cases the first 250 mils of percolate are set aside as finished fluidextract, and, when batch No. 4 is exhausted, the weak percolates Nos. 1, 2, 3, and 4, properly labeled, are placed in some dark, cool place, there to remain until the next time that the fluidextract must be made. The quantity given in above illustration is purely proportional and, of course, does not mean that 950 mils fluidextract must be made each time. The 950 mils fluidextract —that is, the four portions 200 mils plus 250 mils plus 250 mils plus 250 mils—is to be carefully mixed and placed in proper container, and, of course, the next time the fluidextract is to be made from the weak percolates, the amount of the finished product will be 1000 mils.

This attractive and largely used process has been found by the writer to have a fatal weakness. The assumption that the 950 mils of so-called "fluidextract" contains the activity of 950 of the 1000 Gm. of drug used in the process cannot be verified on careful investigation. The amount of extractive in the 950 mils depends on the skill of the operator and practically never in the writer's experiments did he obtain anything like the strength indicated.

In the present pharmacopœia, repercolation is abandoned even as an alternative measure and in its place Type Process C—*fractional or divided* *percolation*—has been substituted. In this the 1000 gm. of drug are divided into three portions of 500, 300 and 200 Gm. each. From the 500 Gm. 200 mils of percolate are set aside as the reserved portion and 1500 mils of weak percolate is then collected in portions of 300 mils each. The 300 Gm. of drug is percolated with the weak percolates just suggested. The first 300 mils of percolate are reserved; while 800 mils of weak percolate are collected in 200 mil portions. These are used to percolate the last 200 Gm. of drug; 500 mils of percolate being collected as reserve portion. Thus 1000 mils of what is supposed to be finished fluidextract are obtained from 1000 Gm. of drug.

Percolation with Incomplete Exhaustion.—In this process, 1000 Gm. of the drug are taken, moistened, packed and carefully percolated until 750 mils of fluid are obtained. The marc is then thrown away and operation is discontinued.

This process assumes that the first 750 mils of percolate from 1000 Gm. of drug will contain the activity of 750 Gm. of the drug employed. In the writer's investigation, such results were rarely obtained; he finding that 500 or at the most 600 mils of percolate from a sample of drug contained in each mil the activity of a gramme of the drug. This process can be employed with good results, if the procedure given below is followed.

A sample of 50 Gm. of drug is percolated to exhaustion and the amount of extract is determined by evaporation of the percolate and weighing of the residue. Then 1000 Gm. of the same batch of drug is percolated until 500 mils of percolate are obtained. Fifty mils of this percolate is evaporated to dryness and the residue weighed and by comparison of the amount of extractive in the 500 mils of percolate with the total extractive in the drug, as shown in the 50-Gm. sample, it is easy to calculate how much menstruum must be added to the 500 mils of percolate in order to make it of true fluidextract strength.

Percolation and Maceration with Hydraulic Pressure.—This process was introduced by a firm of manufacturing pharmacists, but has been abandoned by them in favor of repercolation or fractional percolation, which is employed by almost all large manufacturers.

The process consists of taking a large quantity of the drug—say, 1000 kilos—macerating with a lesser quantity of menstruum—say, 300 liters—and, after a certain time, pressing this liquid by hydraulic pressure. The press cake is returned to the macerating vat, moistened with another 300 liters of liquid, which is pressed out. The process is then repeated with a sufficient quantity of menstruum, so that when it is pressed the third time the quantity of pressed liquid, or official fluidextract, will amount to 1000 liters.

Preservation of Fluidextracts.—Fluidextracts keep well, as a rule, and the precipitate, often occurring, is almost invariably inert. Do not think that home-made fluidextracts are poor because there is a sediment in them after a few months. The manufacturers' fluidextracts do the same thing, only they are kept in the factory long enough to allow complete precipitation; then they are filtered and bottled.

It must be borne in mind, however, that in some cases the precipitate formed in fluidextracts contains a valuable constituent, and in this case the precipitate should be retained. Unfortunately, we have as yet no table showing us which precipitates should be retained and which rejected, and, therefore, at present it is customary always to dispense fluidextracts in a clear form.

SPECIAL NOTES ON THE OFFICIAL FLUIDEXTRACTS

There is such great sameness in most of the 49 official fluidextracts that what is said about one of them applies with equal force to almost all the others. Their strength is identical; their manufacture, as to minor details, is similar, with only a few exceptions to break the monotony. Their medical properties are those of the drugs from which they are derived, and will be left for discussion—as in all other galenics—until the constituent drug is considered. Their doses, which will be grouped at the close of this section, are usually the same as the constituent drug, the only notable exception being the case of fluidextract of senna (which see).

Hence, while there are a large number of official fluidextracts, they can be discussed in a comparatively small space, and instead of giving, as with the other galenics, a table of preparations followed by specific mention of each fluidextract, we can, after study of the general formula for fluidextracts given in the pharmacopœia, present the data concerning most of the individual fluidextracts in tabular form. Before presenting the table, it should be noted that while in U.S.P. VIII there were 85 official fluidextracts, in U.S.P. IX there are monographs for only 49. Most of those deleted have been given recognition in the National Formulary.

OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS A. (See p. 239.)

FLUIDEXTRACTUM BELLADONNÆ RADICIS—Fluidextract of Belladonna Root

(Fldext. Bellad. Rad.—Fluid Extract of Belladonna Root)

One hundred mils of Fluidextract of Belladonna Root yields not less than 0.405 Gm. nor more than 0.495 Gm. of the alkaloids of belladonna root.

Condensed Recipe.

Belladonna Root in No. 40 powder (1000 Gm.) is percolated with the menstruum, alcohol, 5 volumes; water, 1 volume. Of the percolate, the first 800 mils are reserved, the rest is evaporated to a soft extract, which is dissolved in the reserved portion. After assay of a portion of this fluid, it is diluted with enough menstruum to make it the proper alkaloidal strength. For details, see U.S.P., p. 178.

Remarks.—This fluidextract is taken as the type simply because it is the first representative of the class appearing in the pharmacopœia. In studying the recipe given above it will be found that the menstruum used throughout the process consists of alcohol, 5 volumes; water, 1 volume; that the drug is to be in a No. 40 powder and that 800 mils of percolate are to be reserved. It will also be noted that in the case of alkaloidal drugs, the product, obtained when the soft extract is dissolved in the reserved portion, is assayed and is then diluted to the proper alkaloidal strength. In making fluidextracts of non-alkaloidal drugs, on the other hand, the liquid resulting from dissolving the soft extract in the reserved portion is immediately diluted with enough menstruum to make 1 liter. All these points are mentioned, since they form the basis of difference between this and the other fluidextracts of the same class. These other fluidextracts will be found below, grouped according to menstruum employed.

OTHER OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS A

Menstruum	Name	Fineness of powder	Remarks
Alcohol (U.S.P.)	Buchu.	No. 40.	
	Cannabis.	No. 30.	Assay given.
	Cimicifuga.	No. 40.	
	Ginger.	No. 40.	
	Podophyllum.	No. 40.	
	Staphisagria.	No. 20.	Remove separating oil by chilling and filtration.
	Veratrum Viride.	No. 40.	
Alcohol, 5 volumes; water, 1 volume	Digitalis.	No. 30.	Assay given.
Alcohol, 4 volumes; water, 1 volume	Eriodictyon.	No. 30.	
	Gelsemium.	No. 40.	
	Rhubarb.	No. 30.	
	Sabal.	No. 20.	
	Sumbul.	No. 30.	
Alcohol, 3 volumes; water, 1 volume	Eucalyptus	No. 30.	
	Grindelia	No. 30.	
	Guarana.	No. 60.	Assay given.
	Hyoscyamus.	No. 40.	Assay given.
	Nux vomica.	No. 40.	Assay given.
	Xanthoxylum.	No. 30.	
Alcohol, 2 volumes; water, 1 volume	Colchicum seed	No. 40.	Seeds first defatted with purified petroleum benzin; assay given.
	Pilocarpus.	No. 30.	Assay given.
	Viburnum prunifolium.	No. 30.	
Diluted alcohol	Gentian.	No. 30.	
	Sarsaparilla.	No. 20.	
	Spigelia.	No. 40.	
	Stillingia.	No. 30.	
Alcohol, 1 volume; water, 2 volumes	Senna.	No. 40.	

OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS B

FLUIDEXTRACTUM ASPIDOSPERMATIS—Fluidextract of Aspidosperma

(**Fldext. Aspidosp.**—Fluid Extract of Aspidosperma—**Fluidextract of** Quebracho)

Condensed Recipe.

Aspidosperma in No. 30 powder (1000 Gm.) is percolated with the initial menstruum—glycerin, 110 mils; alcohol, 670 mils; water, 220 mils—and then with the final menstruum—alcohol, 2 volumes; water, 1 volume. Reserve the first 850 mils of percolate, recover the alcohol from the remainder, evaporate it to a soft extract, which is then dissolved in the reserved portion. Lastly add enough of the final menstruum to make 1 liter of fluidextract. For details, see U.S.P., p. 177.

Remarks.—The fluidextracts made with menstrua containing glycerin are placed in a class separate from those made with purely hydro-alcoholic menstrua, because there is a slight difference in the method of manipulation. As seen in the above typical recipe, in making 1000 mils of the fluidextract, only the first 1000 mils of menstruum contains glycerin; the rest of the menstruum required being merely alcohol and water. This necessitates, in the table given below, two columns for menstrua, the column headed "final menstruum" being that employed after the first 1000 mils of menstruum (if 1000 Gm. of drug are being percolated) are used up. Bear in mind that if repercolation is used, the first (glycerinic) menstruum is used through the entire operation. The same obtains with those fluidextracts prepared with a menstruum containing acid and these are therefore included in the table given below.

In making fluidextracts of alkaloidal drugs of this class, the liquid obtained by dissolving the soft extract in the reserved portion is assayed and is then diluted with the menstruum to the proper alkaloidal strength.

OTHER OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS B

Menstruum	Name	Fineness of powder	Reserved portion	Final menstruum	Remarks
Glycerin 100 Alcohol 600 Water 200	Hydrastis	No. 40	750 mils	Alcohol, 2 Water, 1	Assay given
Glycerin 100 Alcohol 500 Water 400	Pomegranate	No. 30	850 mils	Diluted alcohol	
	Rose	No. 20	850 mils	Diluted alcohol	
	Sarsaparilla, compound	No. 20	850 mils	Diluted alcohol	See p. 247
	Taraxacum	No. 30	850 mils	Diluted alcohol	
Glycerin 100 Alcohol 300 Water 500	Uva Ursi	No. 30	800 mils	Alcohol, 1 Water, 2	
Glycerin 100 Diluted hydrochloric acid 100 Alcohol 800	Cinchona	No. 40	850 mils	Alcohol, 4 Water, 1	Assay given
Diluted hydrochloric acid 100 Alcohol 200 Water 200	Ipecac	No. 60	800 mils	Alcohol, 2 Water, 3	Assay given
Hydrochloric acid 20 Diluted alcohol 980	Ergot	No. 40	850 mils	Diluted alcohol	
Acetic acid 50 Alcohol 500 Water 400	Lobelia.	No. 30	850 mils	Diluted alcohol	

It will be noticed that the last four fluidextracts on the table just given are prepared with an initial menstruum containing acid; this being added to fix and to hold in solution, the alkaloid characteristic to the drug. The last on the list is fluidextract of lobelia which is made with an initial menstruum containing acetic acid. In the former pharmacopœia, this fluidextract was prepared with 10 per cent. acetic acid as menstruum and was one of the class of acetic fluidextracts (acetracts) which were then being recommended. This line, however, did not become very popular.

OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS C

FLUIDEXTRACTUM ACONITI—Fluidextract of Aconite

(Fldext. Aconit.—Fluid Extract of Aconite)

One hundred mils of Fluidextract of Aconite yields not less than 0.45 Gm. nor more than 0.55 Gm. of the ether-soluble alkaloids of aconite. If assayed biologically the minimum lethal dose should not be greater than 0.00004 mil for each gramme of body weight of the guinea-pig.

Condensed Recipe.

Aconite, in No. 40 powder (1000 Gm.), is percolated a menstruum consisting of 3 volumes of alcohol and 1 volume of water. The process of fractional percolation (see p. 241) is followed. As this is an assayed fluidextract, 920 mils of percolate are collected, a portion is assayed and the rest is diluted with the menstruum to the proper alkaloidal strength.

Remarks.—This preparation typifies the three fluidextracts prepared by fractional or divided percolation; the others being tabulated below. Note that both a chemical and a biological assay is provided for fluid extract of aconite.

OTHER OFFICIAL FLUIDEXTRACTS PREPARED BY TYPE PROCESS C

Menstruum	Name	Fineness of powder	Remarks
Alcohol..............	Aromatic.	....	Made from aromatic powder U.S.P.
Alcohol, 3; water, 1....	Bitter orange peel.	No. 20.	

OFFICIAL FLUIDEXTRACTS MADE BY TYPE PROCESS D

FLUIDEXTRACTUM CASCARÆ SAGRADÆ—Fluidextract of Cascara Sagrada

(Fldext. Cascar. Sagr.—Fluidextractum Rhamni Purshianæ, U.S.P. VIII Fluid Extract of Cascara Sagrada)

Condensed Recipe.

Cascara Sagrada, in No. 40 powder (1000 Gm.), is mixed with 5000 mils of boiling water; is macerated for two hours and is percolated, enough boiling water being used to exhaust the drug. The percolate is evaporated to 750 mils and then 250 mils of alcohol are added. For details see U.S.P., p. 179.

Remarks.—This preparation is representative of those fluidextracts which are prepared by percolating the drug with boiling water, followed by the evaporation of the percolate to the proper volume, after which enough alcohol is added to preserve the finished product.

Fluidextract of Frangula is prepared exactly as is that of cascara sagrada, except that a No. 30 powder is directed.

Fluidextract of Triticum is likewise a close copy of that of cascara sagrada, the chief differences being that the triticum is to be finely cut, and the aqueous percolate is to be evaporated to 800 mils, 200 mils of alcohol then being added.

Aromatic fluidextract of cascara sagrada and **fluidextract of glycyrrhiza** belong in the class of aqueous fluidextracts preserved with alcohol, but the methods by which they are prepared are sufficiently different to justify giving each special attention a few pages farther on.

SPECIAL FLUIDEXTRACTS

Under this heading are grouped the few remaining official fluidextracts which either do not lend themselves to the grouping followed on the preceding pages, or possess some peculiarity worthy of special mention.

FLUIDEXTRACTUM SARSAPARILLÆ COMPOSITUM—Compound Fluidextract of Sarsaparilla

(**Fldext. Sarsap. Co.**—Compound Fluid Extract of Sarsaparilla)

Condensed Recipe.

Ingredients.—Sarsaparilla, 750 Gm.; glycyrrhiza, 120 Gm.; sassafras, 100 Gm.; mezereum, 30 Gm. First menstruum, glycerin, 100 mils; alcohol, 500 mils; water, 400 mils. Final menstruum, diluted alcohol.

Manipulation.—Proceed as in making fluidextract of aspidosperma.

Remarks.—This preparation belongs to those fluidextracts prepared by Type Process B, and the only reason it is grouped in the special class is because it is the only official "compound" fluidextract. Note carefully the ingredients, and it must be borne in mind that it does not contain the same constituents as the compound syrup of sarsaparilla, and it must in no instance, therefore, be used in preparing the official compound syrup.

FLUIDEXTRACTUM CASCARÆ SAGRADÆ AROMATICUM—Aromatic Fluidextract of Cascara Sagrada

(**Fldext. Cascar. Sagr. Arom.**—Fluidextractum Rhamni Purshianæ Aromaticum, U.S.P. VIII. Aromatic Fluid Extract of Cascara Sagrada)

Condensed Recipe.

Ingredients.—Cascara sagrada, 1000 Gm.; magnesium oxide, 125 Gm.; pure extract of glycyrrhiza, 40 Gm.; glycerin, 200 mils; alcohol, 250 mils; benzosulphinide, 1 Gm.; oil of anise, 2.5 mils; oil of cassia, 0.2 mil; oil of coriander, 0.1 mil; methyl salicylate 0.2 mil; boiling water, enough to make 1 liter.

Manipulation.—Mix the cascara sagrada with the magnesium oxide and with 2000 mils of boiling water. Macerate two hours, percolate with boiling water to exhaustion. Evaporate percolate to 500 mils, and add the other ingredients. For details see U.S.P., p. 180.

Remarks.—This fluidextract is made by Type Process D, all general details being like the other fluidextracts of this class. The important distinction is the treatment of the drug, before percolating, with magnesium oxide, this being done to remove most of the bitter taste from the cascara sagrada (p. 791). Note, of course, the constituents added to make the product true to its name, "aromatic," these constituents being extract of glycyrrhiza; oils of anise, cassia and coriander; and methyl salicylate.

FLUIDEXTRACTUM GLYCYRRHIZÆ—Fluidextract of Glycyrrhiza

(**Fldext. Glycyrrh.**—Fluid Extract of Glycyrrhiza. Fluidextract of Licorice)

Condensed Recipe.

Moisten glycyrrhiza (1000 Gm.) with the menstruum—ammonia water, 300 mils; chloroform water, 2700 mils. Macerate forty-eight hours after packing and then percolate to exhaustion. Reserve first 500 mils of percolate, evaporate the rest to a soft extract, dissolve this in the reserve portion and add enough water to make 750 mils. Add 250 mils of alcohol, let stand seven days, filter and wash the filter with a mixture of alcohol and water to make 1 liter. For details, see U.S.P., p. 185.

Remarks.—This preparation is made by percolating the drug with a cold mixture of ammonia water and chloroform water; the latter being used instead of water in order to prevent fermentation of the glycyrrhiza during percolation. It will be noted that the first 500 mils of percolate (from 1000 gm. of drug) are reserved, while the weak percolate is evaporated to a soft extract, which is dissolved in the reserved portion. The amount of alcohol added to the product (250 mils) is merely to insure the stability of the finished fluidextract. This fluidextract of glycyrrhiza is similar to the popular commercial forms intended "for quinine mixtures," and is much superior to the alcoholic fluidextract of the pharmacopœia of 1890.

FLUIDEXTRACTUM SENEGÆ—Fluidextract of Senega

(Fldext. Seneg.—Fluid Extract of Senega)

Condensed Recipe.

Senega, in No. 30 powder (1000 Gm.), is moistened the menstruum—alcohol, 2000 mils; water, 1000 mils. Macerate forty-eight hours after packing and then percolate to exhaustion. Reserve the first 800 mils of percolate; evaporate the rest to a soft extract, which is dissolved in the reserved portion. Then add enough ammonia to make product faintly alkaline and enough menstruum to make 1 liter.

Remarks.—This, like fluidextract of glycyrrhiza, is prepared with a menstruum containing ammonia. In the case of glycyrrhiza, however, the menstruum is aqueous; whereas senega is percolated with a hydro-alcoholic menstruum and ammonia water is added after percolation. The ammonia is used with glycyrrhiza to facilitate solution of the glycyrrhizin (p. 641). Senega, on the other hand, contains pectinous material (p. 649) and ammonia is employed to prevent gelatinization of the finished fluidextract. It will be noticed that the official recipe resembles Type Process A and that like fluidextract of glycyrrhiza the alcohol employed is chiefly for preservative.

FLUIDEXTRACTUM SCILLÆ—Fluidextract of Squill

(Fldext. Scill.—Fluid Extract of Squill)

If assayed biologically the minimum lethal dose should not be greater than 0.0006 mil of Fluidextract, or the equivalent in Fluidextract of 0.0000005 Gm. of ouabain, for each gramme of body weight of the frog.

Condensed Recipe.

Squill, in No. 20 powder (1000 Gm.) is moistened with the menstruum—alcohol, 2000 mils; water, 1000 mils. The moist drug is macerated two hours before and forty-eight hours after packing and is percolated with the menstruum. After collecting the first 1000 mils of percolate the drug is allowed to macerate for twelve hours and after the second 1000 mils are collected the drug is macerated again. Then a third percolate of 3000 mils is collected. The entire percolate is evaporated (recovering the alcohol) to 800 mils. This is mixed with alcohol, allowed to stand twelve hours and then filtered, the filter being washed with a mixture of 4 volumes of alcohol and 1 volume of water. The filtrate is distilled (to recover the alcohol) and is concentrated to 800 mils. Finally enough diluted alcohol is added to make 1 liter. For details see U.S.P., p. 192.

Remarks.—It will be noticed that in the recipe just given, the squill is percolated with a hydro-alcoholic menstruum; that the entire percolate is then concentrated (the alcohol being recovered); and that the concentrated aqueous fluid is mixed with alcohol, in order to precipitate the mucilaginous matter that was contained in the percolate. The filtrate and strongly alcoholic washings are again concentrated, enough diluted alcohol being added to the concentrate to make the finished fluidextract a stable product.

Compound Fluidextract of Buchu (N.F.) is made from ground buchu, cubeb, juniper and uva ursi, by Type Process A; the menstruum being 2 volumes of alcohol and 1 volume of water. *Dose.*—2 mils (30 minims).

Fluidextract of Chestnut leaves (N.F.) is prepared by making a hot infusion of castanea and after separating the liquid by expression, the marc is exhausted by percolation with cold water. The aqueous extract is then concentrated, mixed with alcohol (to precipitate mucilage) filtered and the filtrate concentrated. To the evaporated liquid glycerin and alcohol are added. A similar preparation, recognized in the pharmacopœia of 1880, was reported as of service in whooping cough. *Dose.*—4 mils (1 fluidrachm).

Aqueous Fluidextract of Cinchona (N.F.) is prepared by percolating red cinchona with water containing glycerin and hydrochloric acid. The manipulation resembles Type Process B; the final menstruum being water. To the concentrated percolate, there is added enough alcohol to preserve it. It should contain 4.5 to 5.5 per cent. of cinchona alkaloids and an assay is given. It resembles Battley's Liquid Cinchona, a preparation that was very popular in England and this country a score of years ago. *Dose.*—1 mil (15 minims).

Compound Fluidextract of Stillingia (N.F.) is prepared from stillingia, corydalis, iris, sambucus, chimaphila, coriander and xanthoxylum berries, by Type Process B. The first menstruum consists of glycerin, 250; alcohol, 500; water, 250; while the final menstruum is diluted alcohol. *Dose.*—2 mils (30 minims).

Fluidextract of Wild Cherry (U.S.P. VIII; N.F. IV) is made by moistening wild cherry bark first with a mixture of glycerin and water; then with a mixture of alcohol 2 volumes and water 1 volume. The moistened drug is then percolated with the menstruum just mentioned and the fluidextract is finished by what is practically Type Process B. This manipulation is not that which obtained in the recipe of the last pharmacopœia, which directed that 1000 Gm. of drug be percolated with a menstruum consisting of alcohol, water and glycerin until 1000 mils of percolate were obtained. *Dose.*—2 mils (30 minims).

FLUIDEXTRACTS OF THE NATIONAL FORMULARY

NOTE.—The Type Processes A, B, C, and D are the same as those of the pharmacopœia. Instead of Latin and English names, the name of the drug only is given.

Name	Type process	First menstruum	Final menstruum	Remarks (figures indicate dose)
Adonis	A	Alcohol, 3; water, 1.	None.	0.125 mil (2 minims).
Aletris	A	Diluted alcohol.	None.	2 mils (30 minims).
Angelica root	A	Alcohol.	None.	2 mils (30 minims).
Apocynum	B	Glycerin 100; alcohol, 600; water, 300.	Alcohol 3; water, 2.	0.75 mil (12 minims). Use cautiously. Biological assay given.
Aralia	A	Alcohol, 2; water, 1.	None.	2 mils (30 minims).
Arnica flowers	A	Diluted alcohol.	None.	1 mil (15 minims).
Asclepias	A	Diluted alcohol.	None.	2 mils (30 minims).
Baptisia	A	Alcohol, 3; water, 1	None.	1 mil (15 minims).
Berberis	A	Diluted alcohol.	None.	2 mils (30 minims).
Boldo	A	Alcohol.	None.	0.5 mil (8 minims).
Buchu compound				See p. 248.
Calendula	A	Alcohol.	None.	No dose given.
Calumba	B	Glycerin, 100; alcohol, 800 water, 100.	Alcohol 4; water, 1.	2 mils (30 minims).
Catnip	A	Alcohol, 3; water, 4.	None.	4 mils (1 fluidrachm).
Caulophyllum	A	Alcohol, 3; water, 1.	None.	0.5 mil (8 minims).
Celery fruit	A	Alcohol.	None.	2 mils (30 minims).
Chestnut leaves				See above.
Chimaphila	A	Diluted alcohol.	None.	2 mils (30 minims).
Chionanthus	A	Alcohol, 3; water, 1.	None.	2 mils (30 minims).
Chirata	A	Diluted alcohol.	None.	1 mil (15 minims).
Cinchona, aqueous				See above.
Coillana	A	Alcohol, 3; water, 1.	None.	1 mil (15 minims).
Coffee	B	Glycerin, 65; alcohol, 250; water, 685.	Alcohol 1; water, 3.	2 mils (30 minims).
Colchicum Corm	A	Alcohol, 2; water, 1.	None.	0.2 mil (3 minims).
Condurango	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Conium	C	Acetic acid, 20; diluted alcohol, 980.	None.	Assay given 0.2 mil (3 minims).
Convallaria flowers	A	Alcohol, 2; water, 1.	None.	0.5 mil (8 minims).
Convallaria root	A	Alcohol, 3; water, 1.	None.	0.5 mil (8 minims).
Coptis	A	Diluted alcohol.	None.	2 mils (30 minims).
Cornus	B	Glycerin, 150; diluted alcohol, 850.	Diluted alcohol.	2 mils (30 minims).
Corydalis	A	Alcohol, 3; water, 1.	None.	0.65 mil (10 minims).
Cotton root bark	A	Alcohol.	None.	2 mils (30 minims).
Cubeb	A	Alcohol.	None.	1 mil (15 minims).
Cypripedium	A	Diluted alcohol.	None.	1 mil (15 minims).
Damiana	A	Alcohol, 3; water, 1.	None.	2 mils (30 minims).
Dioscorea	A	Alcohol, 4; water, 1.	None.	4 mils (1 fluidrachm).

FLUIDEXTRACTS OF THE NATIONAL FORMULARY

Name	Type process	First menstruum	Final menstruum	Remarks (figures indicate dose)
Drosera	A	Alcohol, 2; water, 1.	None.	4 mils (1 fluidrachm).
Dulcamara	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Echinacea	A	Alcohol, 4; water, 1.	None.	1 mil (15 minims).
Euonymus	A	Alcohol, 4; water, 1.	None.	0.5 mils (8 minims).
Eupatorium	A	Diluted alcohol.	None.	2 mils (30 minims).
Euphorbium pilulifera	A	Diluted alcohol.	None.	2 mils (30 minims).
Fucus	A	Alcohol, 3; water, 1.	None.	0.65 mil (10 minims).
Galega	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Geranium	B	Glycerin, 100; alcohol, 600; water, 300.	Alcohol 3 water, 2	1 mil (15 minims).
Hamamelis leaves	B	Glycerin, 100; alcohol, 300; water, 500.	Alcohol 1 water, 2	2 mils (30 minims).
Helianthemum	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Helonias	A	Diluted alcohol.	None.	2 mils (30 minims).
Hops	A	Alcohol, 5; water, 3.	None.	2 mils (30 minims).
Hydrangea	A	Alcohol, 3; water, 2.	None.	2 mils (30 minims).
Iris versicolor	A	Alcohol.	None.	2 mils (30 minims).
Jalap	A	Alcohol.	None.	Sand used in percolation 1 mil (15 minims).
Juglans	B	Glycerin, 100; alcohol, 500; water, 400.	Diluted alcohol.	4 mils (1 fluidrachm).
Juniper	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Kava	A	Alcohol, 3; water, 2.	None.	1 mil (15 minims).
Kola	A	Alcohol, 2; water, 1.	None.	4 mils (1 fluidrachm).
Krameria	B	Glycerin, 100; alcohol, 500; water, 400.	Diluted alcohol.	1 mil (15 minims).
Lappa	A	Diluted alcohol.	None.	2 mils (30 minims).
Leptandra	A	Diluted alcohol.	None.	1 mil (15 minims.)
Lupulin	A	Alcohol.	None.	0.5 mil (8 minims).)
Matico	A	Alcohol, 3; water, 1.	None.	4 mils (1 fluidrachm.
Mezereum	A	Alcohol, 4; water, 1.	None.	No dose given.
Paracoto	A	Alcohol, 9; water, 1.	None.	0.3 mil (5 minims).
Pareira	A	Diluted alcohol.	None.	2 mils (30 minims).
Parsley root	A	Alcohol, 2; water, 1.	None.	2 mils (30 minims).
Phytolacca	A	Diluted alcohol.	None.	Dose, as alterative, 0.1 mil (1½ minims).
Quassia	A	Alcohol, 1; water, 2.	None.	0.5 mil (8 minims).
Quercus	B	Glycerin, 100; alcohol, 500; water, 400.	Diluted alcohol.	1 mil (15 minims).
Rhamnus catharticus	A	Diluted alcohol.	None.	1 mil (15 minims.)
Rhus glabra	B	Glycerin, 100; alcohol, 500; water, 400.	Diluted alcohol.	1 mil (15 minims).
Rubus	A	Diluted alcohol.	None.	1 mil (15 minims).
Rumex	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Sanguinaria	B	Citric acid, 100; water 250; alcohol, 750.	Alcohol 3; water, 1.	0.1 mil (1½ minims).
Scoparius	A	Diluted alcohol.	None.	1 mil (15 minins).
Scutellaria	A	Diluted alcohol.	None.	1 mil (15 minims).
Senecio	A	Alcohol, 2; water, 1.	None.	4 mils (1 fluidrachm).
Serpentaria	A	Alcohol, 4; water, 1.	None.	1 mil (15 minims).
Solanum	A	Alcohol, 2; water, 1.	None.	4 mils (1 fluidrachm).
Stillingia compound				See p. 249).
Stramonium	A	Alcohol, 2; water, 1.	None.	0.05 mil (1 minim).
Thuja	A	Alcohol.	None.	2 mils (30 minims).
Thyme	B	Glycerin, 100; alcohol, 250; water, 650.	Alcohol 1; water, 3.	4 mils (1 fluidrachm).
Trifolium	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Trillium	A	Alcohol, 3; water 1.	None.	2 mils (30 minims).
Valerian	A	Alcohol, 4; water, 1.	None.	2 mils (30 minims).
Verbascum	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).
Verbena	A	Diluted alcohol.	None.	1 mil (15 minims).
Viburnum opulus	A	Alcohol, 2; water, 1.	None.	2 mils (30 minims).
Wild cherry				See p. 249.
Zea	A	Diluted alcohol.	None.	4 mils (1 fluidrachm).

DOSES OF THE OFFICIAL FLUIDEXTRACTS

0.03 mil (½ minim)	Fluidextracts of aconite and gelsemium.
0.05 mil (1 minim)	Fluidextracts of belladonna root, digitalis, ipecac (as expectorant) and nux vomica.
0.10 mil (1½ minims)	Fluidextracts of cannabis, squill, and veratrum viride.
0.15 mil (2½ minims)	Fluidextract of lobelia.
0.2 mil (3 minims)	Fluidextracts of colchicum seed and hyoscyamus.

0.50 mil (8 minims)	Fluidextract of podophyllum.
1.00 mil (15 minims)	Fluidextracts of aromatic, bitter orange peel, cascara sagrada, cimicifuga, cinchona, eriodictyon, frangula, gentian, ginger, rhubarb, sabal and senega.
2.00 mils (30 minims)	Fluidextracts of buchu, cascara sagrada aromatic, ergot, eucalyptus, glycyrrhiza, grindelia, guarana, hydrastis, pilocarpus, pomegranate, rose, sarsaparilla, sarsaparilla compound, senna, stillingia, sumbul, uva ursi, viburnum prunifolium, and xanthoxylum.
4.00 mils (1 fluidrachm)	Fluidextract of aspidosperma, spigelia.
10.0 mils (2½ fluidrachms)	Fluidextracts of taraxacum and triticum.
No dose given by pharmacopœia	Fluidextract of staphisagria.

OFFICIAL FLUIDEXTRACTS DIRECTED TO BE ASSAYED, CHEMICALLY

(Details in Chapter LV)

Fluidextract	*Assayed strength*
Aconite	0.45 to 0.55 per cent. ether-soluble alkaloids from aconite.
Belladonna root	0.405 to 0.495 per cent. alkaloids from belladonna.
Cinchona	4.0 to 5.0 per cent. alkaloids from cinchona.
Colchicum seed	0.36 to 0.44 per cent. colchicine.
Guarana	3.6 to 4.4 per cent. caffeine.
Hydrastis	1.8 to 2.2 per cent. ether-soluble alkaloids from hydrastis.
Hyoscyamus	0.055 to 0.075 per cent. alkaloids from hyoscyamus.
Ipecac	1.8 to 2.2 per cent. ether-soluble alkaloids from ipecac.
Nux vomica	2.37 to 2.63 per cent. alkaloids from nux vomica.
Pilocarpus	0.55 to 0.65 per cent. alkaloids from pilocarpus.

OFFICIAL FLUIDEXTRACTS DIRECTED TO BE ASSAYED BIOLOGICALLY

Fluidextract	*Lethal dose*
Cannabis	(incoördination)
Digitalis	0.0006 mil.
Squill	0.0006 mil.

FLUIDGLYCERATES

This is a class of glycerinic fluidextracts suggested by Beringer, in which instead of alcohol and water, a mixture of glycerin, 500 mils and water, 1500 mils is employed as the first menstruum and chloroform water as the final menstruum; the manipulation being similar to Type Process B used in making fluidextracts. They contain approximately 50 per cent. by volume of glycerin and represent in each mil the activity of 1 Gm. of the drug employed. A general formula is given in the National Formulary for fluid glycerates and special recipes are provided for the following:

Fluidglycerate of Cascara Sagrada, prepared as outlined above from cascara sagrada in No. 20 powder.

Aromatic Fluidglycerate of Cascara Sagrada, prepared by treating cascara sagrada with lime (see p. 791) after which it is percolated with the glycerinic menstruum and then with chloroform water; and a concentrated liquid preparation of bitterless cascara sagrada is obtained by manipulation resembling Type Process B. This concentrate is then mixed with fluidglycerate of glycyrrhiza and with oils of fennel, clove and cinnamon; the finished preparation being adjusted so that each liter represents the strength of 750 Gm. of cascara sagrada and 250 Gm. of glycyrrhiza.

Fluidglycerate of Glycyrrhiza is prepared with a menstruum containing 50 mils of ammonia water in 600 mils of glycerin-water menstruum; the manipulation being like that provided in the general formula.

Fluidglycerate of Krameria is prepared from krameria in No. 20 powder, as outlined above.

Fluidglycerate of Rhubarb is similarly prepared.

WINES

Wines are alcoholic liquids prepared from drugs by the process of solution, maceration, or percolation, differing from tinctures only in the solvent employed—wine being used instead of various strengths of alcohol. While wines represent one of the oldest forms of liquid pharmaceutical preparations, the eight recognized in U.S.P. VIII were dropped in the last revision along with the basic fluids, red wine and white wine; since it was claimed that tinctures and fluidextracts covered the therapeutic needs as far as alcoholic pharmaceuticals are concerned. The National Formulary, however, recognizes the 15 wines tabulated below:

WINES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients and method of compounding (figures show amount used in 1000 mils)	Remarks
Vinum antimonii...	Wine of antimony.	Antimony and potassium tartrate, 4 gm.; boiling distilled water; sherry wine. Made by solution.	Similar to the recipe of U.S.P. VIII. *Dose.*—1 mil (15 minims).
Vinum aurantii compositum.	Compound elixir of orange.	Bitter orange peel; absinthium; menyanthes; cascarilla; Saigon cinnamon; gentian; potassium carbonate; sherry wine. Made by percolation.	*Dose.*—4 mils (1 fluidrachm).
Vinum carnis.......	Wine of beef.	Extract of beef; water; syrup; alcohol; compound spirit of orange; sherry wine. Made by solution.	*Dose.*—8 mils (2 fluidrachms).
Vinum carnis et ferri.	Beef, wine and iron.	Contains ingredients just given and also iron and ammonium citrate and enough ammonia water for neutralisation. Made by solution.	*Dose.*—8 mils (2 fluidrachms).
Vinum colchici cormi.	Wine of colchicum corm.	Colchicum corm, 400 Gm.; alcohol; sherry wine. Made by percolation.	Should assay 0.126 to 0.154 per cent. of colchicine. *Dose.*—0.6 mil (10 minims).
Vinum colchici seminis.	Wine of colchicum seed (U.S.P. VIII).	Fluidextract of colchicum seed, 100 mils; alcohol; sherry wine. Made by solution.	Should assay 0.036 to 0.044 per cent. of colchicine. *Dose.*—2 mils (30 minims).
Vinum ferri.	Wine of iron (U.S.P. VIII).	Iron and ammonium citrate; tincture of sweet orange peel; syrup; sherry wine. Made by solution.	*Dose.*—8 mils (2 fluidrachms).
Vinum ferri amarum.	Bitter wine of iron (U.S.P. VIII).	Iron and quinine citrate; tincture of sweet orange peel; syrup; sherry wine. Made by solution.	*Dose.*—8 mils (2 fluidrachms).
Vinum fraxini	Wine of white ash.	White ash bark; 500 Gm.; alcohol; sherry wine. Made by maceration and percolation.	*Dose.*—4 mils (1 fluidrachm.)
Vinum ipecacuanhæ.	Wine of ipecac (U.S.P. VIII).	Fluidextract of ipecac, 100 mils; alcohol; sherry wine. Made by solution.	Should assay 0.180 to 0.220 per cent total alkaloid. *Dose.*–1 mil (15 minims).
Vinum pepsini.	Wine of pepsin.	Glycerite of pepsin, 200 mils; alcohol; sherry wine. Made by solution.	*Dose.*—8 mils (2 fluidrachms).
Vinum picis.	Wine of tar.	Tar, 100 Gm.; water; alcohol; sherry wine. Pumice as clarifier. Made by trituration and filtration.	*Dose.*—8 mils (2 fluidrachms).
Vinum pruni virginianæ.	Wine of wild cherry.	Wild cherry, 250 Gm.; water; alcohol; sugar; sherry wine. Purified talc as clarifier. Percolate the drug with the menstruum, dissolve sugar in the percolate and then clarify.	*Dose.*—4 mils (1 fluidrachm.)
Vinum pruni virginianæ ferratum.	Ferrated wine of wild cherry.	Tincture of ferric citro-chloride, 80 mils; wine of wild cherry. Made by solution.	*Dose.*—4 mils(1 fluidrachm.)
Vinum rhei compositum.	Compound wine of rhubarb.	Fluidextract of rhubarb, 80 mils; fluidextract of bitter orange peel; tincture of cardamon; sugar; sherry wine. Made by solution.	*Dose.*—4 mils (1 fluidrachm).

OLEORESINS

The pharmaceutic oleoresins are liquid preparations of drugs, containing volatile oil and resin, obtained by percolation of such drug with acetone, ether, or alcohol, and subsequent distillation of the solvent from the dissolved oleoresins.

There are two classes of oleoresins—the *natural oleoresins* and the *pharmaceutic oleoresins*. The former are mixtures of volatile oil and resin exuding from plants, and, as example of these, may be cited the drugs turpentine and copaiba, which are discussed in Chapter XLVII. These are quite different from the pharmaceutic oleoresins defined above as being made by percolation with the appropriate solvent.

It is self-evident that we can prepare pharmaceutic oleoresins only from such drugs as contain volatile oil and resin; that such preparations as "oleoresin of cinchona" and "oleoresin of gentian" are impossible, since neither drug contains oil and resin in appreciable quantities. As drugs containing oil and resin are not very abundant, the number of oleoresins is limited, only six being official.

Manufacture.—The pharmaceutic oleoresins are manufactured by placing the drug *without moistening* in a suitable apparatus, and percolating with the appropriate solvent. When the solvent is distilled from the percolate, there is a small quantity of oily liquid left behind, and this constitutes the official oleoresin.

If the menstruum used in percolation is alcohol, the extraction is carried on in an ordinary percolator; but if the solvent is acetone or ether, extraction in an ordinary percolator is both wasteful and dangerous, by reason of the inflammability of the solvent.

In such cases, percolation must be conducted in apparatus so arranged to reduce evaporation to the minimum. Such a percolator is pictured in Fig. 177. Of course, both percolator and receiving bottle cannot be tightly corked, else the dropping of the liquid would be impossible. Accordingly, the corks closing the tops of the percolator and receiving bottle are pierced by glass tubes drawn to tapering points, through which the air may pass without very great evaporation of the ether.

It is found convenient to connect these glass tubes with a rubber tube, although some sticklers disapprove of the use of the rubber tubing by reason of the contamination, through possible solution, of a small part of the rubber by the vapors of ether as they pass through.

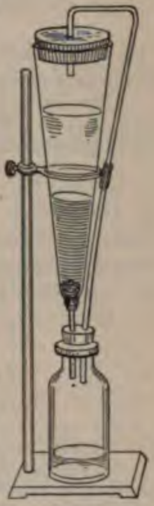

Fig. 177.—Volatile liquid percolator.

Strength.—The strength of oleoresins is uncertain, inasmuch as different samples of the same drug may contain entirely different amounts of their oleoresinous constituent. The oleoresins, however, represent the most concentrated form of liquid pharmaceuticals, being usually from five to ten times stronger than the drug.

TABLE OF OFFICIAL OLEORESINS

(ALL GALENIC)

Solvent	
Ether	Oleoresin of aspidium. Oleoresin of capsicum. Oleoresin of ginger. Oleoresin of parsley fruit. Oleoresin of pepper.
Alcohol	Oleoresin of cubeb.

SPECIAL NOTES ON OFFICIAL OLEORESINS

OLEORESINA ASPIDII—Oleoresin of Male Fern

(Oleores. Aspid.—Oleoresin of Malefern)

Condensed Recipe.

Freshly ground aspidium (500 Gm.) is exhausted by percolation with ether in a volatile liquid percolator. Most of the ether is recovered from the percolator by distillation and residue is freed from the rest of the ether by spontaneous evaporation. For details see U.S.P., p. 282.

Remarks.—The precipitate that forms in this oleoresin consists of the valuable constituent, filicic acid, and this oleoresin must, therefore, be dispensed with a "shake" label.

Note that the drug used must be freshly ground.

Dose.—2 Gm. (30 grains). *Caution.*—Give single dose once a day.

OLEORESINA CAPSICI—Oleoresin of Capsicum

(Oleores. Capsic.)

Condensed Recipe.

Capsicum, in No. 40 powder, is exhausted by percolation with ether. The procedure is exactly as in making oleoresin of aspidium, except that the residue, freed from ether, is filtered through cotton. For details see U.S.P., p. 282.

Remarks.—In preparing the oleoresin, the residue after evaporation of the ether consists of the oleoresin plus a certain quantity of inert fatty substance, which is separated from the valuable liquid by straining through the cotton. The oleoresin of capsicum is used in the preparation of capsicum plaster.

Dose.—30 milligrammes (½ grain).

OLEORESINA CUBEBÆ—Oleoresin of Cubeb

(Oleores. Cubeb.)

Condensed Recipe.

Cubeb, in No. 30 powder, is percolated to exhaustion with alcohol. Most of the alcohol is recovered by distillation and the remainder is removed by spontaneous evaporation. For details see U.S.P., p. 283.

Remarks.—Note that this is the only official oleoresin made by percolating a drug with alcohol. Note that the waxy precipitate is to be rejected, since it is inert and not valuable, as is the precipitate in oleoresin of aspidium. This oleoresin is a constituent of the official *troches of cubeb.*

Dose.—500 milligrammes (8 grains).

OLEORESINA PETROSELINI—Oleoresin of Parsley Fruit

(Oleores. Petrosel.—Liquid Apiol)

Condensed Recipe.

Parsley fruit, in No. 60 powder (500 Gm.), is exhausted by percolation with ether. The procedure is exactly as in making oleoresin of aspidium, except the clear liquid oleoresin is decanted from the solid residue after five days of sedimentation.

Remarks.—This new official is commonly called apiol although it is not the true chemical bearing the name. (See p. 722.) It is used as an emmenagogue and that so frequently illegitimately that in some states its sale is prohibited except upon a physician's prescription.

Dose.—0.5 mil (8 minims).

OLEORESINA PIPERIS—Oleoresin of Pepper

(Oleores. Piper.)

Condensed Recipe.

Pepper, in No. 40 powder (500 Gm.) is exhausted by percolation with ether. The procedure is exactly as in making oleoresin of capsicum; the filtration through cotton being designed to remove the piperin.

Remarks.—This is prepared like the oleoresin of capsicum. After the ether has mostly evaporated, the piperin begins to crystallize from the liquid, and the pharmacopœia directs that these crystals of piperin be removed from the oleoresin by straining through cotton.

This oleoresin is prescribed in the South as *oil of black pepper.*

Dose.—30 milligrammes (½ grain).

OLEORESINA ZINGIBERIS—Oleoresin of Ginger

(Oleores. Zingib.)

Condensed Recipe.

Made like oleoresin of aspidium, except that the drug is to be in a No. 60 powder and not necessarily freshly ground.

Dose.—30 milligrammes (½ grain).

Oleoresina Lupulini (U.S.P. VIII; N.F. IV) is prepared by percolating lupulin with ether. In the last pharmacopœia, acetone was used as the menstruum.

Dose.—0.2 mil (3 grains).

DOSES OF OFFICIAL OLEORESINS

30 milligrammes	(½ grain)	Oleoresins of capsicum, ginger, and pepper.
500 milligrammes	(8 grains)	Oleoresins of cubeb and parsley fruit.
2 grammes	(30 grains)	Oleoresin of aspidium.

VINEGARS

Vinegars are liquid preparations obtained by extracting the active principle of drugs by maceration or percolation with vinegar or with diluted acetic acid.

This is one of the oldest classes of liquid medicinal preparations, and resembles tinctures in everything but the solvent employed. Diluted acetic acid, or its impure form—vinegar,—is an excellent solvent for the active principles of many drugs, and is a preservative as well; hence the ancient uses of medicated vinegars and the former employment of 10 per cent. acetic acid as menstruum in some fluidextracts (p. 245).

However, the vinegars themselves have been largely supplanted by tinctures and fluidextracts, there now being but one—*vinegar of squill*—retained in the pharmacopœia.

ACETUM SCILLÆ—Vinegar of Squill

(Acet. Scill.)

Condensed Recipe.

Squill, in No. 20 powder (100 Gm.), is macerated seven days with diluted acetic acid. The mixture is strained and the strainer washed with enough of the acid to make 1 liter. The strained liquid is heated to boiling, is filtered while hot and finally enough diluted acetic acid is added to make 1 liter. For details see U.S.P., p. 5.

Remarks.—This vinegar is prepared by macerating squill in a No. 20 powder with diluted acetic acid for seven days, and then straining through muslin. The strained liquid is then brought to the boiling-point (in order to coagulate the albumin extracted from the drug), and is filtered while hot.

Since the present official vinegar of squill has been boiled, the official *syrup of squill* prepared from it can be made without boiling of the vinegar, as was directed by the pharmacopœia of 1890.

Dose.—1 mil (15 minims).

Acetum Aromaticum (N.F.) is made by dissolving oils of lavender, rosemary, juniper, peppermint, cinnamon, lemon and clove in alcohol and then adding to the solution acetic acid and water. The alcohol content is about 25 per cent.

Acetum Opii (U.S.P. VIII; N.F. IV) is made by macerating opium, myristica and sugar in diluted acetic acid for seven days after which it is to be filtered by percolation. The former pharmacopœia directed that the opium and myristica be macerated and expressed by successive treatment with two portions of diluted acetic acid (500 and 200 mils each). After filtration, sugar was dissolved in the expressed liquids and enough of the menstruum added to make the finished product represent 10 per cent. of opium. The preparation is known as *black drop;* a dangerous synonym since more than once it has been dispensed with fatal results on prescriptions calling for *black draught* (compound infusion of senna).

Dose.—0.5 mil (8 minims).

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CHAPTER XVI

OFFICIAL LIQUIDS CONTAINING UNDISSOLVED MATTER

MIXTURES

Mixtures are aqueous preparations for internal use containing insoluble non-fatty substances. Since they contain insoluble matter, they must be dispensed with a "Shake Well!" label. They differ from emulsions in containing no fat; from liniments, in being used internally.

Up to the revision of 1890 both mixtures and emulsions were grouped under the common head Mistura, but at that revision the class *emulsions* was given pharmacopœial recognition.

As mixtures usually contain some organic matter, with water as a vehicle, they are prone to fermentation, and are accordingly unstable. A possible exception to this rule is the compound mixture of glycyrrhiza; but even this popular remedy should not be made in too large a quantity.

TABLE OF OFFICIAL MIXTURES

Process	*Galenic preparations*	*Chemical preparations*
All by simple admixture.	Chalk mixture.	Compound iron mixture, U.S.P. VIII.
	Compound mixture of glycyrrhiza.	
	Mixture of rhubarb and soda, U.S.P. VIII.	

SPECIAL NOTES ON OFFICIAL MIXTURES

MISTURA CRETÆ—Chalk Mixture

(Mist. Cret.)

Condensed Recipe.

Ingredients.—Compound chalk powder, 20 Gm.; cinnamon water, 40 mils; water, enough to make 100 mils.

Manipulation.—Triturate the powder with cinnamon water and with some of the water, transfer to a graduated vessel rinsing the mortar with the rest of the water. For details see U.S.P., p. 274.

Remarks.—Chalk mixture is prepared from compound chalk powder, water, and cinnamon water. The object of diluting the cinnamon water is because chalk mixture is very often administered to infants, and the amount of oil of cinnamon in the official cinnamon water may be sufficient to cause an irritation of the mouth. Since compound chalk powder contains the ingredients that are easily fermentable—acacia and sugar—the mixture should be freshly prepared as needed and dispensed to the patient in small quantities—say, four ounces at a time. It is useful in cases of diarrhea.

Dose.—15 mils (4 fluidrachms).

MISTURA GLYCYRRHIZÆ COMPOSITA—Compound Mixture of Glycyrrhiza

(Mist. Glycyrrh. Co.—Brown Mixture)

Condensed Recipe.

Ingredients.—Pure extract of glycyrrhiza, 30 Gm.; syrup, 50 mils; granulated acacia, 30 Gm.; antimony and potassium tartrate, 0.240 Gm.; camphorated tincture of opium, 120 mils; spirit of nitrous ether, 30 mils; water, enough to make 1000 mils.

Manipulation.—Triturate the extract and the acacia with warm water and transfer mixture to a graduated vessel. Add the tartar emetic dissolved in water; then add the other ingredients and enough water to make 1 liter. For details, see U.S.P., p. 275.

Remarks.—This mixture, called *brown mixture*, by reason of its color, is often prescribed in the South under the Latin name "Mistura Fusca" —the latter word being Latin for brown. One physician, evidently thinking the recipe was devised by a man named Brown, was known to prescribe it as "Mistura Browni." Brown mixture is used as a simple remedy in coughs, and for this purpose it is quite efficient.

Dose.—10 mils (2½ fluidrachms).

Mistura Ferri Composita (U.S.P. VIII; N.F. IV) is commonly called *Griffith's mixture.* It contains ferrous carbonate produced by the chemical reaction between ferrous sulphate and potassium carbonate; hence it can best be considered under iron salts in Part III.

Mistura Rhei et Sodæ (U.S.P. VIII) is now recognized in the National Formulary under the name, *mistura rhei composita.* It is made from the fluidextracts of rhubarb and ipecac, sodium bicarbonate, and spirit of peppermint, diluted with glycerin and water and is used in some sections as a remedy for flatulence. It does not, however, enjoy universal popularity. Note that the Formulary also contains a recipe for an alkaline mixture of rhubarb. *Dose.*—4 mils (1 fluidrachm)

MIXTURES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amounts used in 1000 mils)	Remarks
Mistura adstringens.	Villate's mixture.	Solution of lead subacetate; copper sulphate; zinc sulphate; diluted acetic acid.	Used externally as an astringent and escharotic.
Mistura ammonii chloridi.	Mistura solvans simplex.	Ammonium chloride, 25 gm.; pure extract of glycyrrhiza; water.	*Dose*.—8 mils (2 fluidrachms).
Mistura camphoræ acida.	Hope's camphor mixture.	Nitric acid, 17.5 mils; tincture of opium, 12 mils; camphor water.	*Dose*.—8 mils (2 fluidrachms).
Mistura camphoræ aromatica.	Parrish's camphor mixture.	Compound tincture of lavender, 250 mils; sugar; camphor water.	*Dose*.—8 mils (2 fluidrachms.)
Mistura carminativa.	Dalby's carminative.	Magnesium carbonate, 65 Gm.; potassium carbonate, 3 Gm.; tincture of opium, 25 mils; oils of caraway, fennel and peppermint; syrup; water.	*Dose*.—(For infants) 0.5 mil (8 minims).
Mistura chlorali et potassii bromidi composita.	Chloral and bromide compound.	Hydrated chloral, 200 Gm.; potassium bromide, 200 Gm.; extract of cannabis; extract of hyoscyamus; water. Pumice as clarifier.	Resembles *bromidia* and similar proprietary preparations. *Dose*.—4 mils (1 fluidrachm).
Mistura chloroformi et morphinæ composita.	Chloroform anodyne.	Chloroform, 125 mils; ether; tinctures of cannabis and capsicum; morphine sulphate, 2.5 Gm.; oil of peppermint; glycerin; water; alcohol.	*Dose*.—2 mils (30 minims).
Mistura copaibæ.	Lafayette mixture.	Copaiba, 125 mils; spirit of nitrous ether, 125 mils; compound tincture of lavender; solution of potassium hydroxide.	*Dose*.—8 mils (2 fluidrachms).
Mistura copaibæ et opii.	Chapman's mixture.	Copaiba, 250 mils; spirit of nitrous ether, 250 mils; compound tincture of lavender; tincture of opium, 32 mils; mucilage of acacia; water.	*Dose*.—4 mils (1 fluidrachm).
Mistura ferri composita.	....	....	See p. 257.
Mistura guaiaci.	Mixture of guaiac	Tincture of guaiac, 125 mils; clarified honey; cinnamon water.	*Dose*.—15 mils (4 fluidrachms).
Mistura magnesiæ asafœtidæ et opii.	Dewee's carminative.	Magnesium carbonate; tincture of asafetida, 75 mils; tincture of opium, 10 mils; sugar; water.	*Dose*.—8 mils (2 fluidrachms).
Mistura olei picis.	Tar mixture.	Oil of tar; pure extract of glycyrrhiza; sugar; chloroform, 10 mils; oil of peppermint; alcohol; water.	*Dose*.—8 mils (2 fluidrachms).
Mistura oleo-balsamica.	Oleo-balsamic mixture.	Oils of lavender, cinnamon, thyme, lemon and myristica; eugenol; balsam of Peru; alcohol.	Similar to but not identical with *spiritus balsamicus*. *baume de fioraventin* and other allied products.
Mistura opii et chloroformi composita.	Squibb's diarrhœa mixture.	Tincture of opium, 200 mils; spirit of camphor; tincture of capsicum; chloroform, 80 mils; alcohol.	*Dose*.—2 mils (30 minims).
Mistura opii et rhei composita.	Sun cholera mixture	Tinctures of capsicum, rhubarb and opium; spirits of camphor and peppermint; alcohol.	*Dose*.—2 mils (30 minims).
Mistura opii et sassafras	Godfrey's cordial	Tincture of opium, 35 mils; oil of sassafras; alcohol; potassium carbonate; syrup; water.	*Dose*.—(For infants) 0.3 mil (5 minims). A pernicious preparation.
Mistura pectoralis Stokes.	Stokes' expectorant	Ammonium carbonate; fluidextracts of senega and squill; camphorated tincture of opium, 175 mils; water; syrup of tolu.	*Dose*.—4 mils (1 fluidrachm)
Mistura rhei alkalina	Neutralizing cordial	Fluidextracts of rhubarb and hydrastis; potassium carbonate; tincture of cinnamon; spirit of peppermint; syrup; diluted alcohol.	*Dose*.—4 mils (1 fluidrachm.)
Mistura rhei composita.	....	....	See p. 257.

DOSES OF OFFICIAL MIXTURES

10 mils (2½ fluidrachms)	Compound mixture of glycyrrhiza.
15 mils (4 fluidrachms)	Chalk mixture.

LOTIONS

Lotions are fluid preparations, usually containing suspended insoluble matter and applied externally. They differ from mixtures in being designed for external use and from liniments in being aqueous, rather than oleaginous or alcoholic. No lotions are recognized in the pharmacopœia but the following are given place in the National Formulary.

Lotio Ammoniacalis Camphorata (N.F.) is called *sedative water* or *eau sedative de Raspail*. It is made by dissolving sodium chloride in water and adding thereto spirit of camphor and ammonia water. It enjoys considerable popularity in the South as a headache lotion.

Lotio Flava N.F., and **Lotio Nigra**, N.F. will be discussed under the mercurial preparations (Chapter XXXIV).

Lotio Plumbi et Opii, N.F. the well-known *lead and opium wash* is made from lead acetate, tincture of opium and water. (See p. 547.)

Lotio Alba is made by dissolving 5 Gm. of zinc sulphate in 60 mils of rose water; then dissolving 5 Gm. of sulphurated potassa in 60 mils of rose water; then pouring the latter solution into the zinc solution; and lastly adding enough rose water to make 125 mils.

JULEPS AND LOOCHES

Juleps are pleasantly flavored, mucilaginous preparations enjoying some popularity as vehicles in England and in France. A typical julep is the *mistura gummosa* of the earlier German and French pharmacopœias. This is prepared by triturating 10 parts of acacia with 30 parts of syrup of acacia, 100 parts of water and 10 parts of orange flower water. Similar to juleps are the *looches*. Looch blanc or *white linctus* is a type of emulsion of almond.

GARGLES

Gargarismæ or gargles are aqueous preparations containing medicaments intended to relieve throat troubles. The method of application is indicated by the name. The National Formulary gives a recipe for **Gargarisma Guaiaci Compositum** which contains ammoniated tincture of guaiac, compound tincture of cinchona, clarified honey, potassium chlorate (40 Gm. to the liter) oil of peppermint and water. From this it is seen that gargles are not necessarily clear fluids.

EMULSIONS

Emulsions are aqueous preparations for internal use in which resinous or fatty substances are suspended by means of mucilaginous matter. Like mixtures, they must be shaken before administration. A typical emulsion is milk, in which the fat (butter) is emulsified by an albuminous substance, casein. In milk the fat-globules are more finely divided than in any artificial emulsion.

According to the latest ideas of emulsification as advanced by the physical chemists, emulsions are considered to be fine distributions of one liquid in another. The liquid which is dispersed or distributed in fine globules is called the *internal* or *disperse phase*, and the liquid in which the fine globules are suspended is called the *dispersion medium* or *external phase*. There are two types of emulsions used in pharmacy, the oil-in-water type and the water-in-oil type. Almost all emulsions which are intended for internal use, such as cod liver oil, chloroform, etc., belong to the first type, where the oil droplets coated with a film of hydrated acacia are suspended in water. The film around the droplets prevents their running together. Preparations like hydrous wool fat, carron oil, etc., intended for external use are emulsions of the water-in-oil type, in which water is suspended in the form of droplets.

Emulsions, like mixtures, are rather unstable, and should be freshly prepared when desired. This question of freshness may be extended to the statement that no emulsion more than a week old should be dispensed.

The proprietary emulsions which are marketed quite largely are invariably preserved by adding preservatives, the most innocent of which are glycerin or alcohol.

In making emulsions, druggists have the opportunity of exhibiting the highest degree of pharmaceutic art, and there is no reason why the pharmacist should not make all the emulsions he dispenses, except, of course, those proprietary brands specified by the prescriber. Reserving the discussion of the official emulsions until later, we will first consider the important processes of emulsification.

The emulsion of cod liver oil is the best illustration of an emulsion of a fixed oil. It is manufactured by two methods—the English method and the Continental method—and of these, the simplest method of manufacturing is by the Continental method. The secret of the successful manipulation by the Continental method consists in wisely choosing the proportions of gum, water and oil employed, these proportions being: oil, 4 parts; water, 2 parts; and gum, 1 part; or, to express it in other words, use twice as much water as gum, and twice as much oil as water. The manipulation is fully explained in Part VII, and consists of triturating the gum with the oil, and then adding the water all at once, and stirring rapidly until the emulsion results. The emulsion nucleus, as it is called, can be easily diluted with water, syrup, and flavors to the required quantity, it being the general custom in this country to dispense the emulsion of cod liver oil containing 50 per cent. of oil. The objection to the 50 per cent. acacia emulsion is that the resulting product is quite thick and difficult to pour out from a bottle; and, moreover, the use of a large quantity of gum arabic required makes the emulsion rather expensive. For this reason, other gums have been used besides gum arabic, such as tragacanth, Irish moss, gelatin, and dextrin.

Powdered gelatin has also been used in the manufacture of emulsions, and when a combination of powdered gelatin and tragacanth is used, the emulsion can be made in a bottle without the use of a mortar. Powders for the manufacture of these so-called flask emulsions were exploited some years since, and the best known of them, when examined by the author, was found to consist of saponin, saccharin, and a small quantity of a gummy substance. Neither saponin nor saccharin should be used indiscriminately; it is hardly necessary to state that the pharmacist should be chary in employing such substances in emulsions. As for flavoring, various aromatic volatile oils are employed, and various flavoring fluids are given in the admirable general formula for emulsions given in the National Formulary.

Of late, soap is being used as an emulsifier, having the advantage of requiring the use of so small a quantity, that the emulsion is free from soapy taste and that it is more fluid than are gum emulsions.

If an emulsion of castor oil is required, it is made like emulsion of cod liver oil, and the recipe for the same can be found in the National Formulary.

In making emulsions of fixed oils according to the English method, the process consists of triturating gum with water, thus making a mucilage, and adding a small quantity of oil, then adding a little water, and then a little oil, and so on, adding the oil and water alternately until the emulsions are completed. This method of manufacturing the emulsions is slow and uncertain, and cannot be compared in simplicity with the preparation of emulsions by the Continental method. It has, however, the advantage that the comparatively large amount of oil can be emulsified by the addition of a small quantity of gum; and when a physician, therefore, prescribes an emulsion containing less gum than is required by the method of manufacturing according to the Continental method, the English method of emulsification is indicated.

Very frequently the manufacture of emulsion results in a failure, and the product, instead of being a creamy-white product, is an ugly, greasy mixture. This failure in making emulsions is what is called "splitting" an emulsion. Such a split emulsion can be redeemed by adding it gradually to a concentrated perfect emulsion, following the dictum that "the best emulsifier is a perfect emulsion."

Emulsions of volatile oils can be prepared either with gum arabic or tragacanth, although the latter, in the hands of the author, gives more satisfactory results. The manufacture of a typical emulsion of a volatile oil is found in the process given for making emulsion of turpentine (U.S.P.), in which recipe acacia is used as the emulsifier. The recipe can be used for any other volatile oil by substituting such volatile oil for the oil of turpentine in the official recipe.

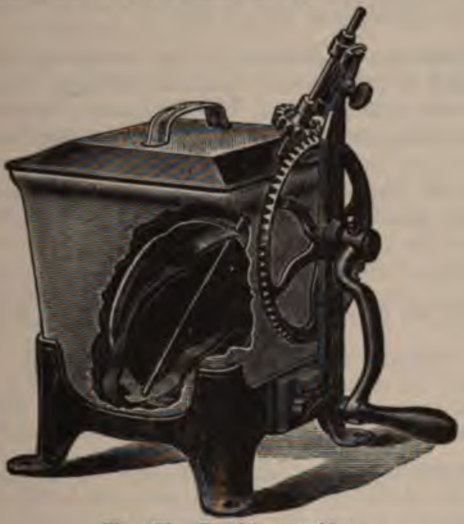

Fig. 178.—Emulsion machine.

In all emulsions that we have thus far considered the emulsifying agent is a gummy substance. Such emulsions have decided limitations, however, the gum being thrown out of the combination by the addition of alcohol, glycerin, or tincture of iron in anything more than in small quantities. For this reason the best emulsifying agent is yolk of egg, and the recipe for emulsion of cod liver oil made with a yolk of egg as a base is found in the National Formulary. Another egg emulsion of cod liver oil is one devised by the author, which is found in Part VII.

Extract of malt is also a valuable emulsifying agent; a recipe is given in the National Formulary. Another satisfactory recipe is as follows: Extract of malt, 1 part; triturate with cod liver oil, 4 parts; then add syrup of wild cherry, 2 parts, and sherry wine, 1 part.

Casein has also been suggested as an emulsifying agent, it being the emulsifier in milk. In the writer's hands, however, the commercial casein has never yielded satisfactory results, nor has he been any more fortunate when using condensed milk, which has been suggested as an emulsifying agent. In working up large quantities of emulsions, a power machine is frequently advisable. Such a machine, operating by hand, is shown in Fig. 178.

TABLES OF OFFICIAL EMULSIONS

(All Galenic)

Gum-resin emulsion	Emulsion of asafetida.
Fixed oil emulsions	Emulsion of almond. Emulsion of cod liver oil.
Volatile oil emulsion	Emulsion of oil of turpentine.

SPECIAL NOTES ON OFFICIAL EMULSIONS

EMULSUM AMYGDALÆ—Emulsion of Almond

(Emuls. Amygd.—Milk of Almond)

Condensed Recipe.

Ingredients.—Sweet almond, 60 Gm.; acacia, 10 Gm., sugar, 30 Gm.; water, enough to make 1 liter.

Manipulation.—Blanch the almonds and beat them in a mortar with the acacia and the sugar; then triturate mixture with water to a smooth mixture. Strain and wash strainer with enough water to make 1 liter.

Remarks.—While this is grouped in the foregoing table as a fixed oil emulsion, we make it from sweet almond (seeds), emulsifying the oil existing therein with gum arabic. The proteids of the almond seed also assist in the emulsification. Note that the almonds must be blanched (p. 663).

The emulsion of almond is also known as *milk of almonds*, and is used as a pleasant vehicle in medicine, although its use in this country is rather limited.

EMULSUM ASAFŒTIDÆ—Emulsion of Asafetida

(Emuls. Asafœt.—Milk of Asafetida)

Condensed Recipe.

Rub asafetida, in tears (40 Gm.) with water to a smooth emulsion. Strain and wash strainer with enough water to make 1 liter. For details see U.S.P., p. 137.

Remarks.—Asafetida, as explained on p. 777, is a gum-resin; it consists of a water-insoluble resin and a water-soluble gum. If we rub asafetida with water, the gum, on dissolving, will emulsify the resin, and a milky mixture, familiarly called *milk of asafetida*, results.

In making this emulsion the whole drug asafetida is placed in a mortar and triturated with water until the emulsion results. Under no circumstances should the powdered drug be used, since the preparation owes its activity to volatile oils, and in getting the drug brittle enough to powder it is necessary to dry it by heat, and this results in driving off an appreciable quantity of the oils. In order to make a good emulsion the best quality of asafetida (tears) should be employed.

The exceedingly unpleasant and persistent odor of asafetida has led to methods of preparing the emulsion in some way other than of triturating the drug in a mortar, for removing the odor from the mortar after making the emulsion is a matter of difficulty. Moreover, since emulsion of asafetida should be freshly prepared, it means that each time a small quantity of the emulsion is called for it is necessary to use the mortar, with the result of keeping it in a continuous state of malodorousness. One method in vogue among certain druggists for making this emulsion—

by diluting the tincture of asafetida with water—is nothing short of criminal, and under no circumstances should it be followed.

Another method that might be criticised, but one which gives fairly good results, is by preparing a glycerite of asafetida by gently warming the gum-resin with glycerin, and thus obtaining a preparation eight times stronger than the emulsion. In preparing the emulsion from this glycerite one drachm of the glycerite is taken and diluted with seven drachms of water. The chief objection to the manufacture of glycerite of asafetida is the uncertainty that the drachm of the glycerite will contain the full active amount of asafetida required for an ounce of the full-strength finished product.

After all, the only safe way is the official method, and as an illustration of financial advantage of being "faithful in small things" may be cited the case of a pharmacist who built up a large prescription business from comparatively small beginnings by calling the attention of physicians in his city to the fact that he made this emulsion, as well as other pharmacopœial staples, "just right."

The disagreeable odor clinging to the utensils used in preparing this emulsion may be combated in two ways.

Best of all is it to have a special mortar for asafetida and other evil-smelling drugs. If that is not feasible, the mortar can be freed from odor by igniting a small amount of alcohol (say one to two fluidrachms) in the mortar, and triturating the burning liquid with pestle until it is burned out. It is needless to say that the pestle handle must be fitted with plaster-of-Paris cement and not with shellac (p. 115), for the latter cement would be softened by the heat of burning alcohol and the handle become loose. Moreover, this method must be cautiously employed, as the sudden heat sometimes cracks the mortar. The same method is of value in removing the odor of iodoform from a mortar.

Dose.—15 mils (4 fluidrachms).

EMULSUM OLEI MORRHUÆ—Emulsion of Cod Liver Oil

(Emuls. Ol. Morrh.)

Condensed Recipe.

Ingredients.—Cod liver oil, 500 mils; powdered acacia, 125 Gm.; syrup, 100 mils; methyl salicylate, 4 mils; water, enough to make 1 liter.

Manipulation.—Triturate the acacia with the oil and with 250 mils of water to an emulsion. Add the methyl salicylate, the syrup and enough water to make 1 liter. If desired, other flavoring can be used instead of methyl salicylate.

Remarks.—Every detail of manipulation of this valuable preparation will be found in Part VII.

Dose.—15 mils (4 fluidrachms).

EMULSUM OLEI TEREBINTHINÆ—Emulsion of Oil of Turpentine

(Emuls. Ol. Tereb.)

Condensed Recipe.

Ingredients.—Rectified oil of turpentine, 15 mils; expressed oil of almonds, 5 mils; syrup, 25 mils; powdered acacia, 15 Gm.; water, enough to make 1 liter.

Manipulation.—Shake the two oils with the acacia in a dry bottle, add 30 mils of water and shake until an emulsion is formed. Add to this, the syrup and enough water to make 1 liter.

Remarks.—Every detail of manipulation of this recipe will be given in Part VI. Note that it contains 15 per cent. oil of turpentine, and the rectified oil at that. Note that a small amount of expressed oil of almond is added to facilitate emulsification.

Dose.—2 mils (30 minims).

Emulsum Ammoniaci (U.S.P. 1890) is a 4 per cent. emulsion of the gum-resin ammoniac made by triturating the drug in the form of tears, with water.

Emulsum Chloroformi (U.S.P. VIII) is prepared by shaking 40 mils of chloroform in a flask with 10 Gm. of powdered tragacanth, and then adding 250 mils of water. After vigorous shaking, 60 mils of expressed oil of almond are added to the mixture in several portions and when the emulsion is completed enough water is added little by little to make 1000 mils of finished product. In making this emulsion, tragacanth is the emulsifying agent, the chloroform being assisted to minute subdivision by means of expressed oil of almond, which also aids in making the emulsion permanent. Note that this is one of the so-called "flask emulsions," being made by shaking the ingredients in a bottle, saving the soiling of a mortar. Another official flask emulsion is emulsion of oil of turpentine, and it might be added that all emulsions of volatile oils can be so made. Emulsions of fixed oils and of gum-resins, on the other hand, should always be made in a mortar.

Dose.—8 mils (2 fluidrachms).

EMULSIONS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Emulsum olei morrhuæ cum calcii lactophosphate.	Emulsion of cod liver oil with calcium lactophosphate.	Cod liver oil, 500 mils; calcium lactophosphate, 50 Gm.; lactic acid; acacia; syrup of tolu; flavoring; water.	*Dose.*—15 mils (4 fluidrachms).
Emulsum olei morrhuæ cum calcii phosphate.	Emulsion of cod liver oil with calcium phosphate.	Cod liver oil, 500 mils; precipitated calcium phosphate, 35 Gm.; acacia; syrup of tolu; flavoring; water.	*Dose.*—15 mils (4 fluidrachms).
Emulsum, olei morrhuæ cum hypophosphitibus.	Emulsion of cod liver oil with hypophosphites.	Cod liver oil, 500 mils; hypophosphites of calcium, potassium and sodium; acacia; syrup; flavoring; water.	*Dose.*—8 mils (2 fluidrachms).
Emulsum olei morrhuæ cum malto.	Emulsion of cod liver oil with malt.	Cod liver oil, *300 mils; tragacanth; water, extract of malt.	See p. 261. *Dose.*—15 mils (4 fluidrachms).
Emulsum olei morrhuæ cum pruno virginiana.	Emulsion of cod liver oil with wild cherry.	Cod liver oil, 500 mils; fluidextract of wild cherry, 65 mils; acacia; syrup of tolu; flavoring; water.	*Dose.*—15 mils (4 fluidrachms).
Emulsum olei morrhuæ cum vitello.	Emulsion of cod liver oil with egg.	Cod liver oil, 500 mils; glycerite of yolk of egg, 175 mils; syrup of tolu; flavoring; water.	See Part VII. *Dose.*—15 mils (4 fluidrachms).
Emulsum olei ricini.	Emulsion of castor oil.	Castor oil, 350 mils; acacia; tincture of vanilla; syrup; water.	*Dose.*—45 mils (1¼ fluidounces).
Emulsum petrolati.	Emulsion of petrolatum.	Petrolatum, 225 Gm.; expressed oil of almond; acacia; syrup; tincture of lemon peel; water.	*Dose.*—15 mils (½ fluidounce).

DOSES OF OFFICIAL EMULSIONS

2 mils (½ fluidrachm).............	Emulsion of oil of turpentine.
15 mils (4 fluidrachms)..............	Emulsions of asafetida and cod liver oil
No dose..........................	Emulsion of almond.

LINIMENTS

Liniments are liquid preparations for external use, applied by friction. Not all official liniments contain insoluble matter, for, as shown in the table of preparations (p. 170), some are clear alcoholic solutions; in fact, but two of the official liniments—ammonia and lime liniments—are opaque. But since some of the rest are alcoholic solutions—such as soap liniment—and some are clear oleaginous solutions—such as camphor liniment—and one is a more or less transparent semisolid mass—turpentine liniment—there seems no definite basis of pharmaceutic grouping of liniments, hence they were left under "liquids containing insoluble matter," to be the last class of pharmaceutic liquids to be discussed.

TABLE OF OFFICIAL LINIMENTS

Consistence		*Basis*	*Galenic preparations*	*Chemical preparations*
Clear liquids.	Alcoholic.	Alcohol.	Soap liniment. Soft soap liniment.	
		Soap liniment.	Chloroform liniment.	
		Fluidextract.	Belladonna liniment.	
	Oleaginous.	Cotton seed oil.	Camphor liniment.	
Opaque liquids.		Sesame oil.		Ammonia liniment.
		Linseed oil.		Lime liniment.
Semisolid.		Oil of turpentine.	Turpentine liniment.	

SPECIAL NOTES ON OFFICIAL LINIMENTS

LINIMENTUM AMMONIÆ—Ammonia Liniment

This preparation, commonly called *hartshorn liniment*, or *volatile liniment*, is a saponaceous emulsion, and will, therefore, be considered among the soaps (Part IV).

LINIMENTUM BELLADONNÆ—Belladonna Liniment

(Lin. Bellad.)

Condensed Recipe.

Camphor (50 Gm.) is dissolved in enough fluidextract of belladonna to make 1 liter. For details, see U.S.P., p. 233.

Remarks.—This consists of the fluidextract of belladonna in which 5 per cent. of camphor is dissolved.

LINIMENTUM CALCIS—Lime Liniment

This liniment (Carron oil) is a saponaceous emulsion, and will, therefore, be discussed in Part IV.

LINIMENTUM CAMPHORÆ—Camphor Liniment

(Lin. Camph.—Camphorated Oil)

One hundred grammes of Liniment of Camphor yields not less than 19.5 Gm. nor more than 20.5 Gm. of camphor. This preparation is not intended for hypodermic use.

Condensed Recipe.

Coarsely powdered camphor (200 Gm.) is dissolved in 800 Gm. cotton seed oil that has been heated on a water-bath. For details see U.S.P., p. 233.

Remarks.—In preparing this liniment (commonly called *camphorated oil*) the pharmacist should be very careful in choosing a winter-strained cotton seed oil, that is, an oil that has been filtered during the cold weather, and, therefore, is freed from dissolved solid matter. If the so-called summer-strained oil is used in making such a liniment, on the first subjection to cold the liniment will become cloudy, and will scarcely reflect credit upon the pharmacist from whom it was bought.

LINIMENTUM CHLOROFORMI—Chloroform Liniment

(Lin. Chlorof.)

Condensed Recipe.

Three hundred mils of chloroform are dissolved by agitation in 700 mils of soap liniment. For details, see U.S.P., p. 234.

Remarks.—This liniment is made by mixing soap liniment and chloroform, and is one of the most valuable of penetrating liniments.

LINIMENTUM SAPONIS—Soap Liniment

(Lin. Sapon.—Liquid Opodeldoc)

Condensed Recipe.

Ingredients.—Soap, 60 Gm.; camphor, 45 Gm.; oil of rosemary, 10 mils; alcohol 700 mils; water, enough to make 1 liter.

Manipulation.—Dissolve the camphor and the oil in the alcohol; then add the soap and the water. Shake until the soap is dissolved; let stand; filter. For details, see U.S.P. p. 234.

Remarks.—Soap liniment is the base of chloroform liniment, and is used quite largely for the extemporaneous preparation of a number of liniments. Thus it is used in preparing a liniment of quinine, which, when applied by friction to children, produces the physiologic effects of quinine without it being taken in by the mouth.

Soap liniment is sometimes called *liquid opodeldoc*, the original being a preparation similar to the official soap liniment, but containing enough soap to render it solid at ordinary temperatures. When the solid opodeldoc is warmed gently, it liquefies. A recipe for solid opodeldoc is found in the National Formulary.

LINIMENTUM SAPONIS MOLLIS—Liniment of Soft Soap

(Lin. Sapon. Moll.—Tincture of Green Soap)

Condensed Recipe.

Dissolve 20 mils of oil of lavender and 650 Gms of soft soap in 300 mils of alcohol. Let stand twenty-four hours, filter and wash the filter with enough alcohol to make 1 liter.

Remarks.—This was called *tincture of green soap* in the pharmacopœia of 1880, and is prepared by dissolving soft soap in alcohol and flavoring with oil of lavender. It is used almost exclusively as an application to the scalp, and is, therefore, the basis of a number of hair-tonics.

LINIMENTUM TEREBINTHINÆ—Turpentine Liniment

(Lin. Terebinth.—Kentish's Ointment)

Condensed Recipe.

Dissolve 650 Gm. rosin cerate, previously melted on a water-bath in 350 mils of oil of turpentine.

Remarks.—This is the only official liniment made with oil of turpentine as a base. It consists of rosin cerate thinned with the volatile oil, and is a semisolid mass that should be dispensed in an ointment jar.

Doses of Liniments.—As all liniments are used externally, no doses are given.

LINIMENTS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 1000 mils)	Remarks
Linimentum aconiti et chloroformi.	Liniment of aconite and chloroform.	Fluidextract of aconite, 45 mils; alcohol; chloroform; soap liniment.	
Linimentum ammonii iodidi.	Liniment of ammonium iodide.	Iodine, 4 Gm.; oils of rosemary and lavender; camphor; ammonia water; alcohol.	
Linimentum opii compositum	Compound liniment of opium	Tincture of opium, 100 mils; camphor; oils of turpentine and peppermint; alcohol; fresh egg albumin; ammonia water.	Sometimes called *Canada liniment.*
Linimentum saponato-camphoratum.	Solid opodeldoc.	....	See p. 266.
Linimentum saponis mollis compositum.	Compound liniment of soft soap.	Soft soap; oil of cade; alcohol.	
Linimentum sinapis compositum.	Compound liniment of mustard.	Volatile oil of mustard, 30 mils; fluidextract of mezereum, 200 mils; camphor; castor oil; alcohol.	
Linimentum terebinthinæ aceticum.	Stokes' liniment.	Oil of turpentine, 400 mils; oil of lemon; acetic acid; fresh egg; rose water.	Also called *linimentum album* and *St. John Long's liniment.*
Linimentum tiglii	Liniment of croton oil.	Croton oil, 130 mils; oil of cajuput; alcohol.	
Linimentum tiglii compositum.	Compound croton oil liniment.	Croton oil, 200 mils; oils of sassafras and turpentine; olive oil.	

LIQUID PETROXOLINS

These are a class of fluid preparations for external use in which the basis is a combination of liquid petrolatum and ammonium oleate.

Petroxolinum Liquidum (N.F.) is made by mixing liquid petrolatum and oleic acid, adding alcohol and then stronger ammonia water and after saponification is completed by use of the heat of a water-bath, oil of lavender is added as a perfume. From this is prepared directly *betanaphthol petroxolin,* (containing 10 per cent. of betanaphthol) *cade petroxolin* (25 per cent. oil of cade), *camphorated chloroform petroxolin* (chloroform and camphor, 25 per cent. each) *creosote petroxolin* (creosote, 20 per cent.) *eucalyptol petroxolin* (20 per cent. eucalyptol) *guaiacol petroxolin* (20 per cent. guaiacol) *diluted iodine petroxolin* (5 per cent. iodine); *iodoform petroxolin* (3 per cent. iodoform dissolved in liquid petroxolin by use of acetone and oleic acid; eucalyptol being used as perfume); *menthol petroxolin* (17 per cent. menthol); *methyl salicylate petroxolin* (20 per cent. methyl salicylate); *phenol petroxolin* (5 per cent. phenol); *camphorated phenol petroxolin* (phenol, 12½ per cent. and camphor, 37½ per cent. are liquefied and are then dissolved in liquid petroxolin); *tar petroxolin* (25 per cent. of oil of tar); *sulphurated petroxolin* (sulphur, 3 per cent., is dissolved in linseed oil and the fluid dissolved in oleic acid and liquid petroxolin; *compound sulphurated petroxolin* (10 parts of sulphurated petroxolin and are diluted to 100 parts, oil of cade, thymol, eucalyptol oil of turpentine and liquid petroxolin being used in the dilution); and *Venice turpentine petroxolin* (20 per cent. Venice turpentine). *Iodine petrox* (10 per cent.) is made by dissolving that amount of iodine in alcohol prior to blending that fluid with the other ingredients required to make liquid petrox.

INFUSED OILS

Olea infusa (N.F.) are a class of oleaginous preparations for external use, made by macerating the drug with alcohol and ammonia water and then digesting the mixture with sesame oil at 60° to 70° until the alcohol and the ammonia water have evaporated. They are supposed to represent in each 1000 Gm., the activity of 100 Gm. of drug. The Formulary gives a general recipe for infused oils, of which the most popular is the *infused oil of hyoscyamus*, which is the basis of the compound oil of hyoscyamus, which is largely used in France, as a remedy for ear-ache under the name *baume tranquille*.

SPRAYS—NEBULÆ

These represent a class of preparations, now largely prescribed by throat specialists, and which consist of light liquid petrolatum in which is dissolved various aromatics and other medicaments. The National Formulary gives recipes for *nebula aromatica* (containing phenol, menthol, thymol, camphor, benzoic acid, eucalyptol, oils of cinnamon and clove and methyl salicylate) *nebula eucalyptolis* (5 per cent.); *nebula mentholis* (2 per cent.); *nebula mentholis composita* (containing menthol, camphor, methyl salicylate, eucalyptol and oil of cinnamon); and finally *nebula thymolis* (1 per cent.). These sprays are employed in atomizers for carrying the medicinal substances into the passages of the throat and lungs.

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CHAPTER XVII

EXTRACTS, ABSTRACTS, RESINS

THESE three classes of preparations include the only solid pharmaceuticals prepared by percolation.

EXTRACTS

Extracts are solid or semisolid preparations of the soluble and active principles of drugs prepared by percolation of the drug with the appropriate menstruum and evaporation of the percolate.

The menstruum employed varies as much as that directed for fluidextracts, being alcoholic, hydro-alcoholic, aqueous, alcoholic and alkaline, or alcoholic and acid.

A special form of extracts, called *inspissated juices*, are popular in England, but have no representative in the present pharmacopœia of the United States. They were, however, represented in the pharmacopœia of 1880 by the then official extract of taraxacum. The present official extract of taraxacum is not an inspissated juice, but is prepared by percolation of the drug with hydro-alcoholic menstruum. Extract of taraxacum (U.S.P. 1890) was scarcely a fair type of the inspissated juices, the most prominent of these being the dried juices from the leaves of plants, and, therefore, containing chlorophyl. Such inspissated juices are prepared by bruising fresh leaves or herbs in a stone mortar, pouring off the greenish liquid, and allowing it to stand over night. The liquid is then strained through calico, thereby separating the chlorophyl; the strained liquid is heated to 200°F., which coagulates the albumin present, and this is removed by straining. The clear liquid is then evaporated to a thin extract, to which is added the chlorophyl, and the whole mixture is evaporated until it is of pilular consistence. Were the plant-juices evaporated to extract directly on separating from the plant, the delicate chlorophyl would be quickly decomposed and a brown extract would result.

By first removing the chlorophyl and evaporating the mixture to a thin extract, the chlorophyl is preserved. When added just as the extract is reaching pilular consistence, it has the effect of giving to it an agreeable green color.

Such inspissated juices, as of aconite, belladonna, and hyoscyamus, are very popular in England, but are scarcely used in this country, and it should be borne in mind that these English "extracts" are much weaker than are the official American extracts.

TABLE OF OFFICIAL EXTRACTS

(ALL GALENIC)

Process	Preparation	Consistence
Percolation with evaporation:		
Menstruum, Alcohol, U.S.P.	Extract of belladonna leaves.	Powdered.
	Extract of cannabis.	Soft.
	Extract of cimicifuga.	Powdered.
	Extract of gelsemium	Powdered.
	Extract of stramonium	Powdered.
Alcohol U.S.P., extract defatted	Extract of colchicum corm.	Powdered.
Alcohol, 4; water, 1	Extract of rhubarb.	Powdered.
	Extract of sumbul.	Soft.
Alcohol, 3; water, 1	Extract of belladonna leaves.	Soft.
	Extract of hyoscyamus	Soft.
	Extract of stramonium.	Soft.
Alcohol, 3; water, 1, extract defatted	Extract of nux vomica.	Powdered.
Diluted alcohol	Extract of colocynth.	Powdered.
	Extract of viburnum prunifolium.	Powdered.
Alcohol, 1; water, 7.	Extract of taraxacum.	Soft.
Tartaric acid; alcohol	Extract of hydrastis.	Powdered.
Tartaric acid: alcohol: extract defatted	Extract of aconite.	Powdered.
Tartaric acid; alcohol, water, extract defatted	Extract of physostigma.	Powdered.
Hydrochloric acid, 10; alcohol, 850; water, 150; Drug defatted	Extract of ergot.	Soft.
Ammonia water, 150 mils, water, 3000 mils	Extract of glycyrrhiza, pure.	Soft.
Water	Extract of gentian.	Soft.
Evaporation of infusion or decoction	Extract of cascara sagrada.	Powdered.
	Extract of malt.	Soft.
	Extract of opium.	Powdered.
Clarification of crude product with alcohol	Extract of oxgall.	Powdered.
A commercial product	Extract of glycyrrhiza.	
A compound extract	Extract of colocynth, compound.	

Of these 25 extracts, 16 are powdered, while 9 are soft, the last class including those of pilular consistence; one thin as honey (extract of malt); and one almost brittle (extract of glycyrrhiza). Two of the official powdered extracts (belladonna and stramonium) are permitted to be dispensed in pilular consistence as well; the directions for manufacture providing for their preparation in either form.

Taking up the several methods of preparing extracts outlined in the table just given, a few words of general explanation of each process may be in place at this time, leaving, of course, minutiæ for consideration under Special Notes.

In the process of *percolation with evaporation*, when the menstruum is hydro-alcoholic, the drug is percolated with the official menstruum and the first portion of the percolate (usually the first 1000 mils from 1000 Gm. of drug) is put aside as a reserved portion. The remainder of the percolate is evaporated at a low temperature to a very small bulk. With this the reserved portion is mixed, and the mass evaporated to pilular consistence.

The manufacture of extracts by this process is one portion of pharmaceutic manufacturing which cannot be done as well by the retail pharmacist as by the large manufacturer. In order to successfully evaporate the extract at a low temperature—say, 70°C.—it is necessary that a vacuum apparatus be employed, and the cost of such an apparatus precludes its use by the retail pharmacist.

In other cases where alcoholic menstruum is employed, none of the percolate is set aside as reserved portion, but the entire percolate is directly evaporated. This is the case where alcohol, U.S.P., is the menstruum, or where the constituents of the drug are not easily injured by heat. Likewise, if the menstruum is water or a diluted acetic acid, there is no reserved portion, but the entire percolate is evaporated.

When the extract is to be brought to a definite strength, if the finished product is to be a powder, starch and magnesium oxide are used as the diluents in the present pharmacopœia while soft extracts are reduced to definite strength by the addition of glucose. Other diluents that are frequently employed are glycyrrhiza and sugar of milk.

The process of *evaporation of infusion or decoction* simply consists of extracting the drug with water—either by infusion or decoction—and evaporation of the watery solution either to pilular consistence or by finishing the product as a powdered extract.

In many respects soft extracts are the least satisfactory of all the official preparations. Thus the phrase, "evaporate to pilular consistence," is rather vague, and the strength of the finished product is apt to be uncertain; not only when first made, but also because, on standing, the strength is apt to change by loss of some of the water the extract contains, the extract becoming hard and dry.

A second factor in the uncertainty of the pilular extracts is the amount of extractive which is contained therein. By the word "extractive" is meant the soluble and inert constituents naturally residing in drugs, grouped, in most text-books of materia medica, as gums, starches, and sugars. These constituents are practically useless from a therapeutic standpoint, and could they be eliminated, the extract would be much stronger. The question of the quantity of the extractive found in the extracts depends entirely on the menstruum employed, one containing a large amount of water yielding a larger amount of extract than those of a strongly alcoholic nature.

The question of the appropriate menstruum for extracting the full strength of the drug without excess of inert matter has been carefully studied by the Committee on Revision of the Pharmacopœia, and the menstruum directed by that standard is the one yielding the most satisfactory results. This menstruum should, therefore, be strictly followed. Yet there have been known unscrupulous manufacturers who deliberately deviate from the pharmacopœial menstruum, adding more water than directed by that standard, in order that large amounts of extract may be obtained. In such cases, of course, an increased yield means a diminution in the active strength of the extract, and it behooves the pharmacist to purchase extracts only from those manufacturers who are known to be reliable.

Among the many constituents which are included in the word "extractive" are the mineral salts, found naturally existing in drugs, such as potassium chloride and sulphate. From many moist extracts on standing the salts crystallize, and such extracts, when rubbed up in making an ointment, are frequently found to be gritty. Whether the grittiness of such extracts is due to crystals or to the accidental mixture of fragments of glass in the container, can be proved by adding a few drops of water and rubbing with an ointment spatula. Should the grittiness dissolve, it shows that it was due to these natural salts; whereas if the grittiness remains after trituration, fragments of glass are indicated.

A third disadvantage in the use of soft extracts is purely pharmaceutic, and that is the inconvenience in handling a semisolid mass. Extracts, especially those of potent drugs, are frequently prescribed in small quantities, say from 1/4 to 1/2 grain. To weigh out the soft extracts it is necessary that the 1/4 to 1/2 grain be weighed on a piece of paper, and by the time the quantity is scraped off the paper and off the spatula, there is frequently very little of the extract transferred to the medicine. It is hardly necessary to say that in weighing such extracts the quantity should be transferred to the paper from the container by means of a perfectly clean spatula, and the spatula cleaned before transferring the weighed portion of the extract into the mortar or other mixture with which it is to be combined. If the surface of paper on which the extract is to be weighed is moistened before "taring," the extract will not stick so closely. Still better is it to use oiled paper or parchment paper.

A fourth inconvenience connected with soft extracts is the uncertainty of the dosage of the extract, due to the uncertainty of the strength of this extract. The variability of the extract-strength is of a twofold character: first, different drugs yield vastly differing quantities of extracts. Thus, gum opium yields about half its weight of soft extract; belladonna and hyoscyamus yield about one-fifth their weight of extracts, while extract of nux vomica is about six times stronger than the drug from which it is obtained.

Hence it is seen that different drugs yield vastly different quantities of extract; not only this, but, worst of all, different batches of the same drug yield different quantities of extract; a very important factor in quality of drugs being the soil on which they have been raised, and particularly the season in which they are collected.

Therefore at their best soft extracts are inconvenient and unreliable, and the revision committee did well in directing that so many of the extracts of the present pharmacopœia be of definite strength, and that the extracts from potent drugs be assayed.

Strength of Extracts.—As just mentioned, many of the extracts of the present pharmacopœia are directed to be of definite strength. A list of these standardized extracts is here given:

OFFICIAL ASSAYED SOFT EXTRACTS

Name	Assayed standard	Percentage of extract to drug	Diluent used
Extract of belladonna leaves.	1.18 to 1.32 per cent. total alkaloids.	400	Glucose.
Extract of cannabis.	Biological assay see Part V.	About 800	Glucose.
Extract of hyoscyamus.	0.22 to 0.28 per cent. total alkaloids.	400	Glucose.
Extract of stramonium.	0.9 to 1.1 per cent. total alkaloids.	400	Glucose.

OFFICIAL ASSAYED POWDERED EXTRACTS

Name	Assayed standard	Percentage of extract to drug	Diluent used
Extract of aconite	1.8 to 2.2 per cent. ether-soluble alkaloids.	400	Starch.
Extract of belladonna leaves.	1.18 to 1.32 per cent. total alkaloids.	400	Magnesium oxide and starch.
Extract of colchicum corm	1.25 to 1.55 per cent. colchicine.	400	Starch.
Extract of hydrastis	9 to 11 per cent. ether-soluble alkaloids.	400	Magnesium oxide and starch.
Extract of nux vomica	15.2 to 16.8 per cent. total alkaloids.	About 600	Magnesium oxide and starch.
Extract of opium	19.5 to 20.5 per cent. morphine.	200	Starch.
Extract of physostigma	1.7 to 2.3 per cent. total alkaloids.	1300	Starch.
Extract of stramonium	0.9 to 1.1 per cent. total alkaloids.	400	Magnesium oxide and starch.

OFFICIAL STANDARDIZED SOFT EXTRACT

Name	Standard
Extract of malt	Sp. gr., 1.35 to 1.40.

OFFICIAL STANDARDIZED SOLID EXTRACTS

Name	Standard	Percentage of extract to drug	Diluent used
Extract of cascara sagrada	300 Gm. from 900 Gm. drug.	300	Magnesium oxide and starch.
Extract of cimicifuga	250 Gm. from 1000 Gm. drug	400	Starch.
Extract of colocynth	250 Gm. from 1000 Gm. drug.	400	Starch.
Extract of gelsemium	250 Gm. from 1000 Gm. drug.	400	Magnesium oxide and starch.
Extract of oxgall	100 Gm. from 800 Gm. drug.	800	Starch.
Extract of rhubarb	500 Gm. from 1000 Gm. drug.	200	Magnesium oxide and starch.
Extract of viburnum prunifolium	200 Gm. from 1000 Gm. drug.	500	Magnesium oxide and starch.

The preservation of extracts should be a matter of more concern than is usually given the subject in the retail pharmacy. Soft extracts should be kept covered sufficiently tight to prevent undue evaporation; since this causes them to become hard, dry lumps. A capital way of keeping extracts is by placing the original containers in which they are obtained from the manufacturer in special extract jars, and thus each extract is protected from the dust.

Powdered extracts—especially those diluted with sugar of milk—should be kept in well-stoppered bottles in a dry place. In contact with moist air they absorb moisture and become sticky masses.

In such cases desiccation and subsequent pulverization will restore the extract to its original form.

Goris suggests preparation of "unaltered plant extracts" by destroying the oxidizing enzymes found in fresh plants by subjecting these to heated alcohol vapors and then extracting the plants so treated with 80 per cent. alcohol and evaporation of alcoholic tincture *in vacuo.*

Commercial extracts—usually prepared by evaporation in a copper vacuum pan—are frequently contaminated with *copper.* This can be detected by sticking a bright steel spatula into the jar of suspected extract and allowing it to remain over night. If copper is present, a coating of the metal will be found on the spatula in the morning.

SPECIAL NOTES ON OFFICIAL EXTRACTS

EXTRACTA—Extracts

The present pharmacopœia under the heading just given, presents a monograph outlining the manufacture and preservation of solid extracts. Most of the information is covered by what is said on pp. 270 to 272 of this book.

EXTRACTUM ACONITI—Extract of Aconite

(**Ext. Aconit.**—Powdered Extract of Aconite)

Extract of Aconite yields not less than 1.8 per cent. nor more than 2.2 per cent. of the ether-soluble alkaloids of aconite and, if assayed biologically, the minimum lethal dose should not be greater than 0.00001 Gm. for each gramme of body weight of the guinea-pig. *One gramme* of the Extract represents about *four grammes* of aconite.

Condensed Recipe.

Aconite in No. 60 powder (1000 Gm.) is moistened with the first menstruum—tartaric acid, 5 Gm.; alcohol, 500 mils. The moist mass is macerated forty-eight hours after packing and is then percolated to exhaustion using alcohol as final menstruum. The first liter of percolate is reserved; the weak percolate is distilled "at as low a temperature as practicable" and the residue is mixed with the reserved portion and the mixture is distilled until a syrupy residue remains. This residue is shaken out with two portions of purified petroleum benzin. The syrupy residue thus treated is then incorporated with 50 Gm. dried starch. The mixture is first dried in a water-bath and finally on glass plates in an air-bath at 70°C. The dried mass is powdered; a portion is assayed and the rest is diluted with dried starch to the proper alkaloidal strength. For details see U.S.P., p. 143.

Remarks.—This extract re-introduced in the present pharmacopœia after an absence since the revision of 1880, is prepared by percolation of the drug with alcohol containing a small amount of tartaric acid. The extract obtained on evaporation of the percolate is then defatted by treatment with purified petroleum benzin after which it is diluted with starch dried on glass plates, assayed and then brought to the proper strength by adding more starch. Note that both chemical and biological assays are provided.

Dose.—10 milligrammes ($\frac{1}{6}$ grain).

EXTRACTUM BELLADONNÆ FOLIORUM—Extract of Belladonna Leaves

(**Ext. Bellad. Fol.**)

Extract of Belladonna Leaves yields not less than 1.18 per cent. nor more than 1.32 per cent. of the alkaloids of belladonna leaves. *One gramme* of the Extract represents about *four grammes* of belladonna leaves. Two forms of this extract are official, the pilular and the powdered form.

The Pilular Extract

Condensed Recipe.

Belladonna leaves, in No. 40 powder (1000 Gm.) is percolated with the menstruum—alcohol, 3 volumes; water, 1 volume—after forty-eight hours maceration in the packed percolator. After the drug is exhausted the entire percolate is concentrated; first by distillation then by evaporation at 70°C.; until a pilular extract remains. A portion of this is assayed and the rest is diluted with glucose to the proper alkaloidal strength.

The Powdered Extract

Condensed Recipe.

Belladonna leaves, in No. 40 powder (1000 Gm.) is percolated with the menstruum—alcohol—after forty-eight hours maceration in the packed percolator. The first liter of percolate is reserved and the rest is distilled, after which the reserve portion is added and the mixture is distilled to a syrupy consistence. This residue is evaporated to pilular consistence at 70°C., is then mixed with dried starch and further heated until it is dry. Then add magnesium oxide and dry in a current of warm air and powder. Assay a portion of the dry extract and dilute the rest with dried starch to the proper alkaloidal strength. For details see U.S.P., pp. 144 to 146.

Remarks.—Two methods are given for this extract—one to produce a powdered, the other to produce a soft extract. Both of these are to be diluted to the same alkaloidal strength. For Assay, see Chapter LV.

Dose.—15 milligrammes (¼ grain).

EXTRACTUM CANNABIS—Extract of Cannabis

(Ext. Cannab.)

Extract of Cannabis, when assayed biologically, produces incoördination when administered to dogs in a dose of not more than 0.004 Gm. of Extract per kilogramme of body weight.

Condensed Recipe.

Take 1000 Gm. cannabis in No. 20 powder, percolate with menstruum—alcohol—and proceed as in making soft extract of belladonna leaves.

Remarks.—It will be noted that a biological assay of this preparation is directed.

Dose.—10 milligrammes (⅙ grain).

EXTRACTUM CASCARÆ SAGRADÆ—Extract of Cascara Sagrada

(Ext. Cascar. Sagr.—Extractum Rhamni Purshianæ, U.S.P. VIII Powdered Extract of Cascara Sagrada)

One gramme of the Extract represents *three grammes* of cascara sagrada.

Condensed Recipe.

Cascara sagrada, in No. 20 powder (900 Gm.) is treated with boiling water and after three hours maceration is percolated to exhaustion adding more boiling water as needed. The percolate is evaporated to dryness on water-bath or steam bath and is mixed with magnesium oxide and with enough dried starch to make 300 Gm. For details see U.S.P., p. 147.

Remarks.—Unlike the extracts already given, this preparation is diluted to a definite weight and not to a certain strength of active ingredient.

Dose.—250 milligrammes (4 grains).

EXTRACTUM CIMICIFUGÆ—Extract of Cimicifuga

(Ext. Cimicif.—Powdered Extract of Cimicifuga)

One gramme of the Extract represents *four grammes* of cimicifuga.

Condensed Recipe.

Take 1000 Gm. cimicifuga in No. 40 powder, percolate with the menstruum—alcohol—and proceed as in making soft extract of belladonna leaves except that the dry residue obtained by evaporation of the percolate is mixed with enough starch to make a powdered extract, 1 Gm. of which represents 4 Gm. of the drug.

Dose.—250 milligrammes (4 grains).

EXTRACTUM COLCHICI CORMI—Extract of Colchicum Corm

(Ext. Colch. Corm.—Powdered Extract of Colchicum Corm)

Extract of Colchicum Corm yields not less than 1.25 per cent. nor more than 1.55 per cent. of colchicine. *One gramme* of the Extract represents about *four grammes* of colchicum corm.

Condensed Recipe.

Colchicum corm, in No. 60 powder (1000 Gm.), is percolated to exhaustion with the menstruum—alcohol—after maceration for forty-eight hours in the packed percolator. The entire percolate is distilled and the residue is shaken out with three portions of purified petroleum benzin. The residue thus treated is concentrated on a water-bath to a thick extract, is mixed with dried starch and is then dried on glass plates in an air-bath at 70°C. A portion of the dried powdered extract is assayed and the rest is diluted with dried starch to the proper alkaloidal strength. For details see U.S.P., p. 148.

Remarks.—It will be noticed that the recipe just given resembles that for making extract of aconite.

Dose.—60 milligrammes (1 grain).

EXTRACTUM COLOCYNTHIDIS—Extract of Colocynth

(**Ext. Colocynth.**—Powdered Extract of Colocynth)

One gramme of the Extract represents *four grammes* of colocynth.

Condensed Recipe.

Take 1000 Gm. colocynth pulp, in No. 20 powder, percolate with the menstruum—diluted alcohol—and proceed as in making extract of cimicifuga (p. 274) except that the maceration is for twenty-four hours; the drug is to be shaken down (not packed) in the percolator and a definite amount of percolate (5000 mils) is to be collected.

Remarks.—This extract is used in making *compound extract of colocynth.*

Dose.—15 milligrammes (¼ grain).

EXTRACTUM COLOCYNTHIDIS COMPOSITUM—Compound Extract of Colocynth

(**Ext. Colocynth. Co.**—Powdered Compound Extract of Colocynth)

Condensed Recipe.

Ingredients.—Extract of colocynth, 160 Gm.; aloes, 500 Gm.; cardamom seed, 50 Gm.; resin of scammony, 140 Gm.; soap, 150 Gm.

Procedure.—Mix the ingredients by trituration and sift. For details see U.S.P., p. 150.

Remarks.—This, the only official compound extract, is prepared by blending extract of colocynth with aloes, cardamom seed, resin of scammony and soap.

This extract contains soap, partly to increase the purgative properties, but chiefly in order that the finished product can be worked into the pill-mass by the addition of water. This explains why, in making compound cathartic pills, water can be used as excipient, the real excipient in this case being the soap contained in the compound extract of colocynth. Used in *compound cathartic pills* (U.S.P.).

Dose.—250 milligrammes (4 grains).

EXTRACTUM ERGOTÆ—Extract of Ergot

(**Ext. Ergot.**)

Condensed Recipe.

Ergot, in No. 40 powder (1000 Gm.) is extracted with purified petroleum benzin. It is then dried, mixed with the first menstruum—hydrochloric acid, 10 mils; alcohol, 340 mils; water, 60 mils—and is macerated six hours and then forty-eight hours after which it is percolated to exhaustion; the final menstruum being alcohol, 850 mils;

water, 150 mils. The entire percolate is concentrated first by distillation, then by evaporation at 70°C. to a pilular extract. For details see U.S.P., p. 150.

Remarks.—This extract is prepared by first defatting the ergot by percolation with purified petroleum benzin after which it is percolated with an acidulated hydro-alcoholic menstruum and the percolate is finally concentrated to a soft extract.

Ergotin is an aqueous extract of ergot. A recipe for such a preparation is given in the National Formulary. (See p. 281.)

Dose.—250 milligrammes (4 grains).

EXTRACTUM FELLIS BOVIS—Extract of Oxgall

(**Ext. Fel. Bov.**—Powdered Extract of Oxgall)

One gramme of the Extract represents *eight grammes* of oxgall.

Condensed Recipe.

Oxgall (800 Gm.) is macerated two days with 1000 mils of alcohol. The liquid portion is then decanted, and the residue is washed with 500 mils of alcohol. The combined alcoholic liquid is then concentrated first by distillation, then by evaporation at 80°C. and residual extract is finally dried on glass plates at 70°C. The dried extract is then powdered and mixed with enough dried starch to make 100 Gm. For details see U.S.P., p. 151.

Remarks.—This "new" official extract is merely a modification of *purified oxgall* of the last pharmacopœa. It consists of oxgall dissolved in alcohol to remove the mucin and other slimy bodies and after decantation and filtration, the alcohol is distilled off, the residue dried and brought to a definite strength by dilution with starch. It is an improved form of the old-fashioned inspissated oxgall.

Dose.—100 milligrammes (1½ grains).

EXTRACTUM GELSEMII—Extract of Gelsemium

(**Ext. Gelsem.**—Powdered Extract of Gelsemium)

One gramme of the Extract represents *four grammes* of gelsemium.

Condensed Recipe.

Gelsemium, in No. 40 powder (1000 Gm.) is moistened with the menstruum—alcohol— is macerated forty-eight hours after packing and is then percolated to exhaustion. The entire percolate is concentrated first by distillation, then by evaporation at 70°C. to a soft extract. This is mixed with magnesium oxide and with dried starch, is dried on glass plates in an air-bath at 70°C. and, after powdering, is mixed with enough magnesium oxide and dried starch to make 250 Gm. For details see U.S.P., p. 152.

Remarks.—While the manufacture of this extract is in some respects like that of powdered extract of belladonna leaves, there are several points of difference in the two recipes. In the first place there is no reserve percolate as obtains in the belladonna recipe and again, the finished extract is adjusted to a definite ratio between weight of drug and of extract, rather than to definite alkaloidal content.

Dose.—10 milligrammes (⅙ grain).

EXTRACTUM GENTIANÆ—Extract of Gentian

(**Ext. Gentian.**)

Condensed Recipe.

Moisten 1000 Gm. gentian in No. 20 powder with water, macerate twenty-four hours before packing and then percolate with water to exhaustion. The entire percolate is concentrated by boiling, is then strained and the strained liquid is evaporated to a pilular consistence on a water-bath. For details see U.S.P., p. 153.

Remarks.—Made by the evaporation of the cold aqueous percolate from gentian, this liquid being strained after concentrating, and then evaporated to pilular consistence. The use of the extract as a pill excipient, so popular in the South, is not to be recommended from the medical point of view (p. 305).

Dose.—250 milligrammes (4 grains).

EXTRACTUM GLYCYRRHIZÆ—Extract of Glycyrrhiza

(**Ext. Glycyrrh.**—Extract of Licorice)

The commercial Extract of Glycyrrhiza.

Description.

This is the commercial extract of licorice, occurring in cylindrical rolls, of characteristic sweetish taste. At least 60 per cent. must dissolve in cold water. Ash, not more than 6 per cent.

Manufacture.—Prepared on a large scale in Italy by evaporating a strained aqueous infusion in vacuum pans, and rolling the extract while still soft into sticks.

Remarks.—This extract is the commercial product known as "stick licorice." Samples found in the market are frequently adulterated with starch and other insoluble matter; hence the pharmacopœial requirement that at least 60 per cent. be soluble in cold water.

EXTRACTUM GLYCYRRHIZÆ PURUM—Pure Extract of Glycyrrhiza

(**Ext. Glycyrrh. Pur.**)

Condensed Recipe.

Moisten 1000 Gm. glycyrrhiza, in No. 20 powder, with the first menstruum—ammonia water, 150 mils; water, 3000 mils—macerate twenty-four hours before packing and then percolate to exhaustion, using chloroform water as the final menstruum. Evaporate the entire percolate on a water-bath to pilular consistence. For details, see U.S.P., 153.

Remarks.—This extract is prepared by percolating the drug with ammoniacal water, and is the soft extract used in *compound mixture of glycyrrhiza* (U.S.P.). Note that the commercial *purified extract of licorice* is usually in powdered form, hence not identical with the official product.

It will be remembered that ammonia is used in the menstrua of most licorice preparations, owing to the fact that the sweet principle, glycyrrhizin, is most easily soluble in alkaline fluids.

EXTRACTUM HYDRASTIS—Extract of Hydrastis

(**Ext. Hydrast.**—Extract of Golden Seal. Powdered Extract of Hydrastis)

Extract of Hydrastis yields not less than 9 per cent. nor more than 11 per cent. of the ether-soluble alkaloids of hydrastis. *One gramme* of the Extract represents about *four grammes* of hydrastis.

Condensed Recipe.

Moisten 1000 Gm. hydrastis in No. 40 powder, with the menstruum—tartaric acid, 5 Gm.; alcohol, 1000 mils. Macerate forty-eight hours after packing and then percolate to exhaustion. Concentrate the entire percolate, first by distillation, then by evaporation at 70°C., to a soft extract, which is mixed with magnesium oxide and dried starch, and is then dried on glass plates in an air-bath at 70°. A portion of the dry extract is assayed and the rest is diluted with magnesium oxide and dried starch to the proper alkaloidal strength. For details see U.S.P., p. 154.

Remarks.—This extract was not recognized in the last pharmacopœia. Its manufacture resembles in some respects the manipulation in preparing extracts of aconite and belladonna.

Dose.—500 milligrammes (8 grains).

EXTRACTUM HYOSCYAMI—Extract of Hyoscyamus

(Ext. Hyosc.)

Extract of Hyoscyamus yields not less than 0.22 per cent. nor more than 0.28 per cent. of the alkaloids of hyoscyamus. *One gramme* of the Extract represents about *four grammes* of hyoscyamus.

Condensed Recipe.

Hyoscyamus, in No. 40 powder, is made into a pilular extract by the same procedure followed in making soft extract of belladonna. For details see U.S.P., p. 155.

Dose.—60 milligrammes (1 grain).

EXTRACTUM MALTI—Extract of Malt

(Ext. Malt.)

Condensed Recipe.

Macerate 1000 Gm. malt (in not finer than No. 12 powder) with 1000 mils of water. Then add 4000 mils of warm water and digest one hour at 60°C. Express the mixture, filter the strained liquid and evaporate the filtrate at 60°C. to a density between 1.350 and 1.400. For details see U.S.P., p. 156.

Remarks.—This is the popular pharmaceutical soft extract of malt and must not be confused with the more or less fermented liquid extract of malt, prepared by brewers.

Dose.—15 grammes (4 drachms).

EXTRACTUM NUCIS VOMICÆ—Extract of Nux Vomica

(Ext. Nuc. Vom.—Powdered Extract of Nux Vomica. Nucis Vomicæ extractum P. I.)

Extract of Nux Vomica yields not less than 15.2 per cent. nor more than 16.8 per cent. of the alkaloids of nux vomica.

Condensed Recipe.

Moisten 1000 Gm. nux vomica, in No. 20 powder, with the menstruum—alcohol, 3 volumes; water, 1 volume. Macerate forty-eight hours after packing and then percolate to exhaustion. Concentrate the entire percolate, first by distillation then by evaporation and shake out the residue with two portions of purified petroleum benzin. The separated benzin solutions are mixed and are in turn shaken out, three times with a weak solution of sulphuric acid. These acid solutions after separation are made alkaline with ammonia and are shaken out three times with chloroform. Finally the mixed chloroformic solutions are added to the evaporated extract, which is then dried by heating on a water-bath. A portion of the dry extract is then assayed and the rest is diluted with magnesium oxide and dried starch to the proper alkaloidal strength. For details see U.S.P., p. 156.

Remarks.—While the recipe just given closely resembles that for making extract of aconite, it shows some notable differences of manipulation. Of these the most marked is the handling of the benzin extract which contains not only the fat from the seed but also possibly some of the alkaloids. These are recovered by shaking out with diluted sulphuric acid and then with chloroform.

Dose.—15 milligrammes (¼ grain).

EXTRACTUM OPII—Extract of Opium

(Ext. Opii—Powdered Extract of Opium. Opii extractum P. I.)

Extract of Opium yields not less than 19.5 per cent. nor more than 20.5 per cent. of anhydrous morphine. *One gramme* of the Extract represents about *two grammes* of opium.

Condensed Recipe.

Macerate 100 Gm. opium cut in small pieces, with hot water and then triturate to a smooth paste. Mix with clean dry sand and percolate mixture with water to exhaustion and then evaporate the entire percolate to dryness on a water-bath. Assay a portion of the dry extract and dilute the rest with dried starch to the proper alkaloidal strength. For details see U.S.P., p. 158.

Remarks.—The recipe of the present pharmacopœia differs from that of U.S.P. VIII, starting in with gum opium (not the powder) and by diluting with starch instead of with sugar of milk.

Dose—30 milligrammes (½ grain).

EXTRACTUM PHYSOSTIGMATIS—Extract of Physostigma

(Ext. Physostig.—Powdered Extract of Physostigma)

Extract of Physostigma yields not less than 1.7 per cent. nor more than 2.3 per cent. of the alkaloids of physostigma. *One gramme* of the Extract represents about *thirteen grammes* of physostigma.

Condensed Recipe.

Moisten 1000 Gm. physostigma in No. 60 powder, with the first menstruum—tartaric acid, 5 Gm.; alcohol, 750 mils; water, 250 mils—and proceed as in making extract of aconite, except that the entire percolate is evaporated. The final menstruum is alcohol 3 volumes; water, 1 volume. For details see U.S.P., p. 158.

Dose—8 milligrammes (⅛ grain).

EXTRACTUM RHEI—Extract of Rhubarb

(Ext. Rhei—Powdered Extract of Rhubarb)

Condensed Recipe.

Moisten 1000 Gm. rhubarb in No. 40 powder with the menstruum—alcohol 4 volumes; water, 1 volume. Proceed as in making extract of cimicifuga except that dry extract is to be diluted with enough magnesium oxide and dried starch to make 500 Gm. For details see U.S.P., p. 160.

Dose—250 milligrammes (4 grains).

EXTRACTUM STRAMONII—Extract of Stramonium

(Ext. Stramon.)

Extract of Stramonium yields not less than 0.9 per cent. nor more than 1.1 per cent. of the alkaloids of stramonium. One gramme of the Extract represents about *four grammes* of stramonium.

Manufacture.—Both soft and powdered extracts of stramonium are directed and the recipes given in the pharmacopœia are identical with those for extract of belladonna (p. 273).

Dose.—10 milligrammes (⅙ grain).

EXTRACTUM SUMBUL—Extract of Sumbul

(Ext. Sumbul)

Condensed Recipe.
Moisten 1000 Gm. sumbul, in No. 30 powder, with the menstruum—alcohol, 4 volumes; water, 1 volume—and proceed as in making extract of cannabis. No assay, however, is provided for the finished extract. For details see U.S.P., p. 162.

Procedure.—Like that followed in making extract of cannabis, except the menstruum (alcohol, 4 volumes; water, 1 volume) and the fact that no assay is provided.

Dose.—250 milligrammes (4 grains).

EXTRACTUM TARAXACI—Extract of Taraxacum

(Ext. Tarax.)

Condensed Recipe.
Moisten 1000 Gm. taraxacum, in No. 30 powder, with the menstruum—alcohol, 125 mils; water, 875 mils—and proceed as in making extract of sumbul. For details, see U.S.P., p. 163.

Dose.—1 gramme (15 grains).

EXTRACTUM VIBURNI PRUNIFOLII—Extract of Viburnum Prunifolium

(Ext. Viburn. Prun.—Powdered Extract of Viburnum Prunifolium)

One gramme of the Extract represents *five grammes* of viburnum prunifolium.

Condensed Recipe.
Moisten 1000 Gm. viburnum prunifolum with the menstruum—diluted alcohol—and proceed as in making extract of gelsemium. The soft extract, however, is dried on glass plates after mixing with magnesium oxide only, and the resulting dry extract is then mixed with enough dried starch to make 200 Gm. For details, see U.S.P., p. 163.

Procedure.—Similar to that followed in making of gelsemium. The menstruum, however, is diluted alcohol, and the drying of the soft extract is directed to be done in a slightly different manner.

Dose.—500 milligrammes (8 grains).

DOSES OF OFFICIAL EXTRACTS

8 milligrammes (⅛ grain)	Extract of physostigma.
10 milligrammes (⅙ grain)	Extracts of aconite, cannabis, gelsemium and stramonium.
15 milligrammes (¼ grain)	Extracts of belladonna leaves, colocynth, nux vomica.
30 milligrammes (½ grain)	Extract of opium.
60 milligrammes (1 grain)	Extracts of colchicum corm and hyoscyamus.
100 milligrammes (1½ grains)	Extract of oxgall.
250 milligrammes (4 grains)	Extracts of cascara sagrada, cimicifuga, colocynth compound, ergot, gentian, rhubarb, and sumbul.
500 milligrammes (8 grains)	Extracts of hydrastis and viburnum prunifolium.
1 gramme (15 grains)	Extract of taraxacum.
15 grammes (4 drachms)	Extract of malt.
No dose given	Extracts of glycyrrhiza and glycyrrhiza pure.

EXTRACTS OF NATIONAL FORMULARY

Name	Consistence	Menstruum	Drug extracted by	Diluent	Strength	Remarks
Aloes	Powdered.	Boiling water.	Infusion.	Starch.	200 per cent. of drug.	*Dose.*—125 milligrammes (2 grains).
Cinchona	Pilular.	Alcohol, 3; water, 1.	Percolation.	Glucose.	22 to 26 per cent. total alkaloids.	*Dose.*—250 milligrammes (4 grains).
Conium	Pilular.	Diluted alcohol.	Percolation.	Glucose.	1.8 to 2.2 per cent. coniine.	Hydrochloric acid added to evaporating percolate. *Dose.*—30 milligrammes (½ grain).
Ergot, aqueous	Pilular.	Chloroform water.	Percolation.	None.	No mention.	Alcohol added to percolate and filtrate evaporated. *Dose.*—200 milligrammes (3 grains).
Euonymus.	Powdered.	Alcohol, 4; water, 1.	Percolation.	Starch.	400 per cent. of drug.	*Dose.*—125 milligrammes (2 grains). Caution!
Apples, ferrated	Pilular.	Apple juice and reduced iron.	....	....	No mention. See p. 614.	*Dose.*—650 milligrammes (10 grains).
Hematoxylon	Powdered.	Water.	Decoction.	None.	No mention.	*Dose.*—1 gramme, (15 grains).
Ignatia	Powdered.	Alcohol, 3; water, 1.	Percolation.	Starch.	5.4 to 6.6 per cent. total alkaloids.	*Dose.*—30 milligrammes (½ grain).
Jalap	Pilular.	Alcohol.	Percolation.	None.	No mention.	*Dose.*—1 gramme. (15 grains).
Krameria	Powdered.	Water.	Percolation.	Starch.	400 per cent. drug.	*Dose.*—500 milligrammes (8 grains)
Leptandra	Powdered.	Alcohol, 3; water, 1.	Percolation.	Starch.	400 per cent. drug.	*Dose.*—250 milligrammes (4 grains)
Podophyllum	Pilular.	Alcohol, 4; water, 1.	Percolation.	None.	No mention.	*Dose.*—15 milligrammes (¼ grain).
Quassia	Powdered.	Water.	Percolation.	Starch.	1000 per cent. drug.	*Dose.*—60 milligrames (1 grain).

ABSTRACTS

Abstracts were a class of preparations introduced into the pharmacopœia of 1880, intended to supplant extracts, they representing powders containing the active principles of drugs in the condensed form, and of definite strength, prepared by percolating the drug with the appropriate menstruum, reserving a certain portion, (say, 90 per cent. of the weight of the drug), evaporating the weak percolate of the drug to a thin extract, blending with the reserve portion and also with sugar of milk; evaporating the mixture at a low temperature until dry. The mass was then weighed, and enough sugar of milk added to make the finished product exactly half the weight of the drug from which it was derived. Such an abstract, therefore, represents twice the strength of the drug.

Abstracts possess over soft extracts the great advantage of being in powdered form and of definite and uniform strength, but, unfortunately, they won little favor from physicians and were dropped in the revision of 1890. Their advocacy was not in vain, however, since in the present pharmacopœia, as already mentioned on p. 269, over half of the official extracts are in powdered form and 18 of the 25 are standardized.

RESINS

While in the chemical sense resins are solid plant substances or exudations usually acid in character, insoluble in water, and soluble in water and alkali, the definition of the pharmaceutic class—resins—are *those* *plant products, soluble in alcohol and insoluble in water, obtained either as the residue from the distillation of an oleoresin, or by pouring a concentrated alcoholic extract of a drug into water or acidulated water.* All three official resins are made by the latter process; but, as example of resins obtained by distillation of an oleoresin, may be cited resin of copaiba (U.S.P. 1890) and official rosin. The latter, however, can best be considered as a crude arug, and is, therefore, discussed in Part IV.

SPECIAL NOTES ON OFFICIAL RESINS

RESINA JALAPÆ—Resin of Jalap

(Res. Jalap.)

Condensed Recipe.

Moisten 1000 Gm. jalap, in No. 60 powder, with the menstrum—alcohol—macerate for forty-eight hours after packing and then percolate with alcohol, to exhaustion. Recover most of the alcohol by distillation and pour the residual liquid (which should weigh 250 Gm.) into 3000 mils of water. After standing decant supernatant liquid, wash the precipitated resin with water, by decantation, and finally dry it by heating on a water-bath. For details see U.S.P., p. 357.

Condensed Description.

Yellow to brown masses or fragments; peculiar odor, acrid taste; soluble in alcohol; insoluble in carbon disulphide; not more than 30 per cent. should dissolve in chloroform.

Impurities.—Rosin, guaiac and other resins; aloin; water-soluble matter. For details see U.S.P., p. 357.

Remarks.—The above recipe—precipitation of resin from the concentrated alcoholic tincture by pouring into water—needs no special comment.

As most pharmacists buy their resins in the open market, and as some of the commercial samples are rankly adulterated, the pharmacopœia gives in the case of all three official pharmaceutic resins tests for identity and for detection of adulterants. Whatever explanation of these tests are needed will be given under the drugs from which the resin is derived in Part IV. A constituent of the official *compound cathartic pills.*

Dose.—125 milligrammes (2 grains).

RESINA PODOPHYLLI—Resin of Podophyllum

(**Res. Podoph.**—Podophyllin)

Condensed Recipe.

Moisten 1000 Gm. podophyllum, in No. 60 powder with alcohol and macerate for forty-eight hours, after packing. Percolate with alcohol to exhaustion; concentrate the percolate by distillation to a thin syrup, which is then poured into a mixture of 10 mils of hydrochloric acid with 1000 mils of water, which has been chilled to 10°C. Let the precipitated resin subside, decant the supernatant fluid; wash the precipitate by decantation, with two portions of cold water; and then collect and dry it on a strainer. For details, see U.S.P., p. 358.

Condensed Description.

Amorphous powder; light-brown to greenish-yellow; peculiar odor; bitter taste; soluble in alcohol; 75 per cent. is soluble in ether; 65 per cent. is soluble in chloroform; hot water extracts some bitter principle which turns brown with ferric chloride; soluble in fixed alkaline hydroxides, with a yellow color; ash, not more than 1.5 per cent.

Impurity.—The resin from *Podophyllum. Emodi.*—See U.S.P., p. 359.

Remarks.—The pharmacopœial recipe differs from that for resin of jalap in the volume to which the tincture must be concentrated; in the quantity of water in which the precipitation is performed, and in the fact that it must be acidulated and cold, and that the wash-water must be cold.

The question of temperature and composition of the precipitation liquid is of great importance in making this and other resinoids. Some manufacturers precipitate podophyllin by pouring into alum solution, securing a larger yield and a less active product. Unless the precipitation is properly conducted there is danger of obtaining a markedly toxic product.

This resin is the most important of the so-called *"resinoids,"* a class of preparations introduced by eclectic practitioners, through whose efforts a large number of valuable American drugs—such as podophyllum and hydrastis—were brought to the attention of physicians.

In attempting to secure concentrated forms of these eclectic drugs Dr. King hit upon the idea of extracting the drug with strong alcohol and pouring this alcoholic tincture into water. In this way he obtained resin of podophyllum, and so named it. Later manufacturers, supposing it a definite body, called it "podophyllin."

Like many other excellent ideas, the search for such concentrates was carried to excess, and thus were put upon the market a number of *resinoids*, each purporting to be the active principle of the plant from which derived, and given the name implying such active constituent. Among such resinoids of little or no value may be cited *aletrin* (from *Aletris farinosa*); *geranin* (from *Geranium maculatum*); *macrotin* (from *Cimicifuga racemosa*, the other botanical name of which is *Macrotrys actæoides*); and *sanguinarin* (from *Sanguinaria canadensis*). How these commercial names lead to confusion can best be shown by the statement that the resinoid, sanguinarin, has nothing in common with sanguinarine, the alkaloid of sanguinaria.

Resin of podophyllum is a constituent of a number of pills included in the National Formulary. (See p. 313.) It is not used however, in any preparation of the present pharmacopœia.

Dose.—10 milligrammes (1/6 grain).

RESINA SCAMMONII—Resin of Scammony

(Res. Scamm.)

Condensed Recipe.

Moisten 1000 Gm. scammony root in No. 30 powder with alcohol, macerate forty-eight hours after packing and percolate with alcohol to exhaustion. Concentrate the percolate by distillation and pour the residual thin syrup into hot water. After standing, the supernatant liquid is decanted from the precipitated resin, which is washed by decantation with two portions of hot water and then dried on a water-bath. For details see U.S.P., p. 359.

Condensed Description.

Brownish translucent masses, of characteristic fragrant odor; soluble in alcohol, 95 per cent. is soluble in ether; soluble in alkali hydroxides; ash, not more than 1 per cent.

Impurities.—Rosin, guaiac and resins of jalap and false scammony. For details see U.S.P., p. 359.

Remarks.—In making this resin the manipulation is similar to that employed in preparing resins of jalap and of podophyllum; the difference being absence of mention of amount of alcohol used in moistening the drug, of the volume of percolate and of evaporated fluid. Note that the precipitation is to be in unacidulated hot water.

Dose.—200 milligrammes (3 grains).

Resina Copaibæ (U.S.P. 1890) was included in a number of the editions of the United States Pharmacopœia but was dropped in the eighth revision. It is made by distilling the oleoresin, copaiba, when the volatile oil passes over, leaving the resin in the retort.

DOSES OF OFFICIAL RESINS

10 milligrammes (1/6 grain)..........	Resin of podophyllum
125 milligrammes (2 grains)..........	Resin of jalap.
200 milligrammes (3 grains)..........	Resin of scammony.

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CHAPTER XVIII

POWDERS AND TRITURATIONS

POWDERS

A DEFINITION for powders is somewhat difficult unless we are satisfied with the rather vague statement, *combinations of solid drugs in finely divided form.*

It is even questionable whether powders should be grouped under "internal preparations," for while all official powders are used internally, there are many prescriptions for powders intended for dusting purposes. Powders are usually made by trituration with pestle and mortar, though dusting-powders should be made by mixing the ingredients, already reduced to a fine powder, with a spatula, since rubbing in a mortar is apt to cause caking.

In writing prescriptions for compound powders the physician usually directs the trituration of a sufficient quantity of the ingredients to make several powders. This is particularly useful from the point of the physician in enabling him to prescribe a certain weighable quantity of a potent drug, say, one grain of arsenic, and directing that to be rubbed up with the other constituents, and then to be dispensed in a sufficient number of parts, so that each part will contain a safe dose. Thus, if a grain of arsenic is directed in 30 powders, each powder will contain the usual dose of that chemical (1/30 grain). In preparing such powders it is necessary for the pharmacist to exert great caution in having the potent ingredient sufficiently triturated with the diluent to insure uniform and thorough subdivision. The dividing of the mass into the requisite number of powders is accomplished in several ways. In one the papers, which are to hold the several portions of the divided powder, are spread on a clean table; the mixture transferred to the papers in portions by means of the spatula, and when all the substance has thus been transferred, an attempt is made to equalize the quantity of powder on each paper by means of the eye. With practice one becomes fairly expert at striking the requisite quantity, although the process, at its best, is inaccurate, as can be proved by any pharmacist by taking at random three or four powders from the batch that is thus divided and weighing each. A variation of 25 to 30 per cent. is not unusual.

In order to render the subdivision more accurate, several appliances for the dividing of powders have been devised. Of these the most convenient is the Michael powder divider (Fig. 179). This consists of a tapering cup into which the mixed powder is poured and packed fairly uniformly by gentle tapping. Into this is then inserted a special separator consisting of metal segments, which exactly divide the cup into the number of powders desired, thus equally dividing the powder into the desired portions. This being done, the apparatus is covered with a tightly fitting cap, provided with one orifice, through which the contents of compartments of the divider can be poured off one at a time. By turning the cap so that the orifice changes from segment to segment, and inverting after each case, the contents of each segment can be emptied. At its best, however, such a powder divider is not exceedingly convenient, nor is it so correct as one would wish.

The third, and by all odds the best, method of dividing powders is by estimating the weight that each powder should be, and weighing out that quantity, and transferring it forthwith to one of the unfolded papers. In this way correct results are obtained, and when once practised, the process is found to demand but little more time than that consumed in dividing by eye. In weighing powders it is found, however, by reason of the extreme accuracy of the process, that the last powder is apt to be short in weight, due to the natural loss because of some of the powder adhering to the pestle and mortar. In the writer's practice he always weighed out a sufficient amount of each ingredient called for in the prescription to make one more powder than the number directed, and the slight excess, after weighing out the requisite number of papers, was then thrown away. The powders so divided are then folded in separate pieces of paper; the art of powder-folding being one acquired with a little practice. The process consists in laying the requisite number of papers on the clean table, each provided with a fold at the top, the size of which has been determined in advance. The subsequent processes will best be shown in the appended illustrations (Fig. 180), the second stage being to bring up the lower edge of the paper to the crease already made, as shown in *b*. The flap of the crease is then bent over on to the edge, the paper then taken and creased and folded down to the lower edge of the paper, and then all that remains is that the two edges be folded inward, as shown in *c*. The folding of these ends, so that the length of each folded paper be the same, is sometimes performed on a special powder-folder, shown in Fig. 181, although many careful pharmacists fold the paper as directed upon the box into which the finished powders are to be placed.

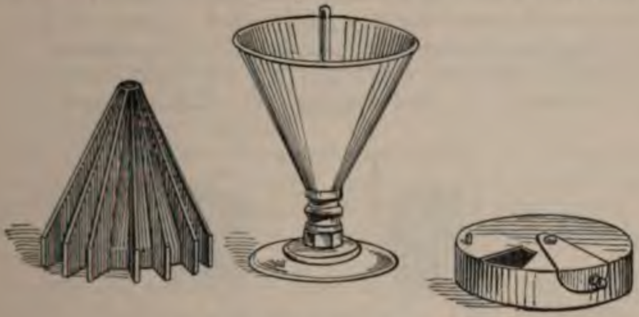

Fig. 179.—Michael's powder divider.

There are now on the market powder papers folded by machinery and intended to be used by opening, putting in the powder, and folding again, but the writer fails to see wherein these give better results than a plain paper folded by hand, as directed below.

In discussing the question of the various forms of powder boxes, it is necessary here to say that modern pharmacists use the so-called New York powder box, shown in Fig. 182, slide powder boxes failing to give as good results. Into this New York powder box the powder should be placed upright, as is shown in Fig. 180, *e*, and in folding the powder each should be exactly the same size, and should project from the box to the same height—usually made about $\frac{1}{16}$ inch. The finer grade of the powder box is arranged with a sufficient difference between the height of the shoulder and of the inside of the cover to permit the papers to protrude that distance, the object of having the papers protrude being to facilitate the removing of the papers from the box.

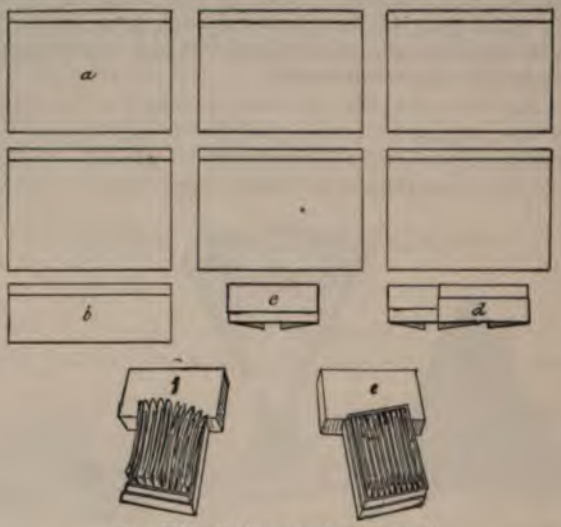

Fig. 180.—Folding powders (see text).

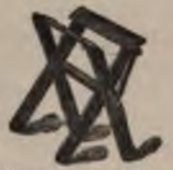

Fig. 181.—Powder folder.

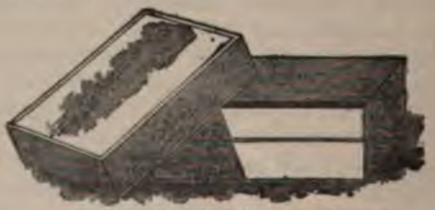

Fig. 182.—New York powder box.

In preparing and successfully folding the paper it is necessary that the paper conform exactly to the dimensions of the box, and in order to aid the pharmacist in this work, the so-called shoulder boxes are made the same length and height, the difference in the size for the different numbers of papers being merely in the width. In purchasing boxes of that kind the pharmacist should procure paper of such size as will make a perfectly neat package; that is, a paper the length of which is a trifle less than double the interior length of the box, while the width of the paper should be a little over twice the height of the box. Having obtained paper of the right dimensions, all that remains to be done is to learn the size which the first flap (Fig. 180, *a*) should be made. This is so regulated that the powder, when folded, with the end where the original flap was made coinciding with the finished folded paper, will make a finished powder of the height suggested above, namely, one which will protrude 1/16 inch from the paper box.

Having folded a paper to conform with the size of the box, it is customary to make the finished powder smooth by rubbing each end down with a spatula. The powders are then gathered up from the counter and piled together with the flaps alternating up and down (Fig. 180, *d*). These precautions are required because it will be seen that the finished powder is thicker where the flap rests than in any other portion of the paper. If the bunch of powders, say 12 to 24, were placed in a box, all in the same position, this slight increase in thickness, multiplied by the number 12 or 24, would make a decided discrepancy in the width of the top and bottom of a bunch of powders; and if such were placed in the box in which they fit snugly, a decided pressure would be exerted at the upper edge, a pressure, in fact, sufficient to cause the springing out of the entire lot of powders when the first paper was removed (Fig. 180, *f*). By alternating the position of the flap up and down the pressure is equalized and no such inconvenience results.

Some pharmacists follow the admirable custom of having their name and address printed on their powder papers in such a position that the printed matter will appear in the center of the folded paper. Such a practice cannot be too strongly recommended, because it affords a highly legitimate method of publicity.

After the powders are neatly folded and placed in the box, the latter is wrapped in an appropriate paper and tied. This leads us to the very important question of the dispensing of packages in elegant form, an art which appears to the writer to be falling into disuse. The first essential in making a successful package is that the paper be of exactly proper proportions, and the writer attributes to the introduction of the roll paper, so largely used in drug-stores at present, and supposed to be unrolled and torn off as required, the lack of care shown in the modern package.

In former days the paper was bought in full sheets and was carefully cut to the size required for the package. Thus, for powder boxes the paper was cut in strips 4 inches wide, and of a length ranging from 6 inches to 8 inches. For pill boxes smaller strips, say 2½ inches wide, were employed. The paper for 1-ounce bottles was 6 by 6 inches, for 2- and 3-ounce bottles was 7 by 8½ inches; for 4- and 6-ounce bottles was 8½ by 11 inches; for 8-ounce bottles was 11 by 11 inches; while for pint bottles it was 12 by 12 inches. Of the papers so cut, the one for 6-ounce bottles usually sufficed for the careful wrapping of 1 to 2 ounces of an herb, and from 4 to 8 ounces of a chemical; while the larger sized papers would be used for proportionately larger quantities. The criticism that might be raised in regard to taking pains in making packages is the time which is required. As far as the wrapping of a powder or pill box or of a bottle, no more time is required for wrapping it carefully than is required to do the same work carelessly, and as for the wrapping of solid substances, it is recommended that the pharmacist follow the custom of old-time druggists of keeping on hand a sufficient stock of packages already wrapped, which can be handed out when demanded. In the author's experience, he kept on hand packages of almost everything for which there was at least one demand a week. Of those substances for which there was a very slight demand, only one package was prepared and kept in the container, and when this was sold, another package was made at the first leisure moment. In this way the pharmacist, especially when by himself in a store, can facilitate dispensing to an enormous extent, because much time is consumed in wrapping packages. Details of making a neat package can be best given accompanied by the following illustrations:

Wrapping a pill box: Take the strip of paper, place the pill box thereon, and bring up the two ends, and fold over into a crease, as is shown in Fig. 183, *a*. The paper should be made of such a size that a second crease about the size of the first one will bring the paper perfectly firmly around the edge of the pill box, as shown in *b*. The paper should then be of sufficient width so that when the edges are folded down in the flap, there will be bulging pieces of paper to be cut off. In the writer's experience, he preferred folding the open edges down to the folded flaps, as shown in *c*, because when so done the tying can be done by simply passing the string two or three times around the edge of the box, as is shown in *d*. Some pharmacists prefer to bring the edges down, as is shown in *e*, when the string must be placed, not merely around the edges, but around the edges of the box, as is shown in *f*. In place of twine, elastic bands are now used, and have much to commend themselves.

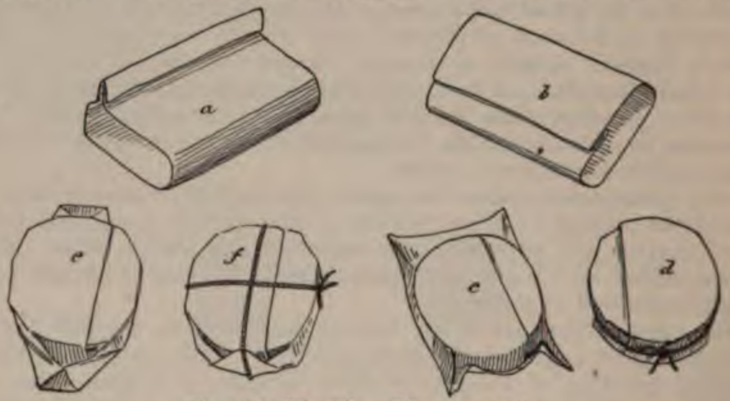

Fig. 183.—Wrapping pill box (see text).

In wrapping a powder box the procedure is similar to that of a pill box, as shown in the various stages in Fig. 184, *a* and *b*. The flaps are folded either as shown in *c* or *d*, and for the same reason as explained in the case of the pill boxes.

In wrapping bottles the mode of procedure is, first, to fold the crease, as shown in Fig. 185, *a*, and, as in the case of the powder and pill boxes, the paper should be of such a size that the second fold will bring the paper snugly around the bottle, as shown in *b*. The open edge at the base of the bottle is then folded in neat flaps, while the paper around the neck should be creased, as shown in *c*.

This done, the bottle is wrapped with string down and back, and finally wound tightly around the neck, as is shown in *d*.

In folding packages the paper is first folded with the crease, as shown in Fig. 186, *a*. This crease is then bent, very great care being required to make it exactly equal the whole length of the package, as shown in *b*. One of the open ends is then temporarily folded, as shown in *c*, while the other end is carefully folded away from the flap, as shown in *d*. This being done, it is then turned downward, the temporary folding of the other end reopened, and refolded exactly as the other end, the finished package is then wrapped with a string, both across its length and width, as shown in *e*, although for this purpose a rubber band is frequently substituted.

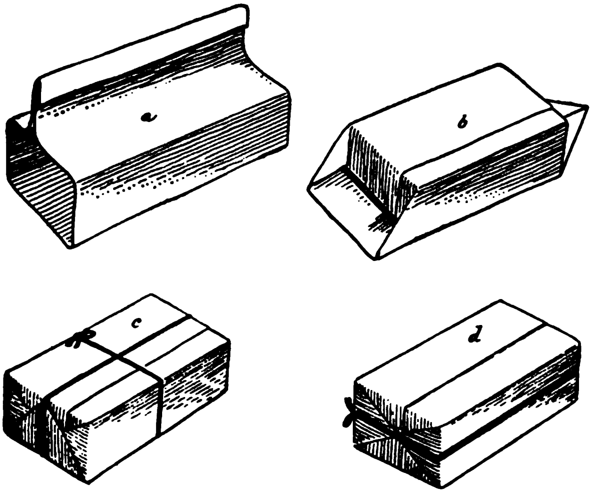

Fig. 184.—Wrapping powder box (see text).

The folding of solids in packages, as just mentioned, is becoming obsolete, due to the introduction of boxes for holding solid substances at prices justifying their free distribution by the druggist.

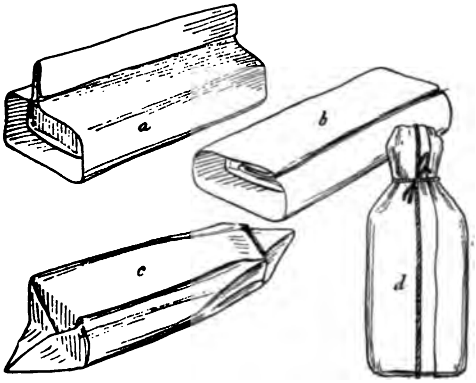

Fig. 185.—Wrapping bottle (see text).

Such boxes should be wrapped with paper in a manner similar to the smaller powder boxes, and the use of such boxes is growing very popular because of the convenience of keeping drugs in such containers. It might be here stated that all packages of drugs and chemicals wrapped in the style above given should be neatly labeled.

As to the choice of wrapping-paper, the writer uses plain white paper in preference to the gaudily colored papers so much in vogue in modern pharmacies. He is not alone in this preference, for not long since a woman of refinement and culture spoke of the shocking lack of taste displayed by the average druggist in dispensing his drugs in gaudy pink, blue, and red paper. The manila paper, formerly largely used for the cheaper goods, should not be used by elegant dispensers; such paper is admirably adapted to the wrapping of packages to be sent by mail or express, but it should not be seen wrapped around any product taken out of the drug-store by the purchaser.

In place of string or rubber bands there has been lately introduced an attractive form of fastener in the shape of ribbon on which is imprinted the name of the firm. Although such ribbon is expensive, the use of it is good business, affording the pharmacist a convenient and unobtrusive method of publicity.

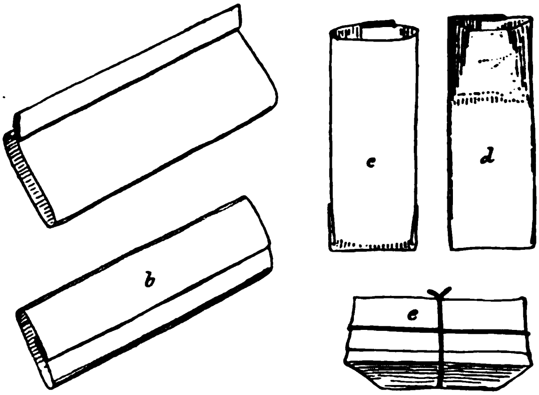

Fig. 186.—Wrapping package (see text).

To return to the subject of the dispensing of powders: if the powder contains deliquescent substances, the ordinary powder paper should not be used, as the moisture will soon penetrate to the ingredients and the paper will become wet. Such deliquescent powders should be wrapped in paraffin paper and then covered with tin-foil in order to prevent, as far as possible, atmospheric action.

The *powders of the pharmacopœia* represent mixtures of the medicinal constituents not divided into specific doses, the only exception of this rule being Seidlitz powder.

Even as all the pharmacopœial liquids—such as tinctures and fluidextracts—are directed to be finished as bulk fluids of definite strength, so all official powders except Seidlitz powders are to be finished as bulk masses. In this way the pharmacopœial powders differ from such official solids as pills, lozenges, and suppositories, which are finished in the form of divided doses.

TABLE OF OFFICIAL POWDERS
(All Galenic)

Process	*Preparation*
All by simple trituration. Finished in undivided masses.	Aromatic powder. Chalk powder, compound. Glycyrrhiza powder, compound. Powder of ipecac and opium. Powder of jalap, compound. Powder of rhubarb, compound.
Finished in divided doses.	Effervescing powder, compound.

SPECIAL NOTES ON OFFICIAL POWDERS

PULVIS AROMATICUS—Aromatic Powder

(Pulv. Arom.)

Condensed Recipe.

Ingredients—Saigon cinnamon and Jamaica ginger, of each, 35 Gm.; cardamom seed and myristica (freshly grated), of each, 15 Gm.

Manipulation.—Triturate the cardamom and nutmeg, with a portion of the cinnamon and then with the rest of the ingredients.

Remarks.—This consists of cinnamon, ginger, cardamom, and nutmeg. The present pharmacopœia directs the use of cardamom seed, deprived of pericarps (the chaffy wall of the ovary constituting the so-called "hull"). This is to be crushed and then triturated to a fine powder with nutmeg and a little cinnamon, blended with finely powdered ginger and cinnamon. Both the cardamom and nutmeg are very unstable in the powdered form; hence the whole drugs are to be powdered in the process of preparation.

It is to be noted that the present pharmacopœia provides a paragraph describing the microscopy of this powder.

Aromatic powder is used chiefly to flavor other powdered substances, although it is of some value for relieving flatulence.

Dose.—1 Gm. (15 grains).

PULVIS CRETÆ COMPOSITUS—Compound Chalk Powder

(Pulv. Cret. Co.)

Condensed Recipe.

Ingredients.—Prepared chalk, 30 Gm.; powdered acacia, 20 Gm.; powdered sugar, 50 Gm.

Manipulation.—Mix by simple trituration and sift. For details, see U.S.P.

Remarks.—This is the chief constituent of *chalk mixture* (p. 257), and is official for that reason alone.

Note that it is made from prepared chalk, not from precipitated chalk, for reasons given on p. 471.

Dose.—2 Gm. (30 grains).

PULVIS EFFERVESCENS COMPOSITUS—Compound Effervescing Powder

(Pulv. Eff. Co.—Seidlitz Powder)

The weight of a mixture in a blue paper is not less than 9.5 Gm. nor more than 10.5 Gm. and contains not less than 23 per cent. nor more than 27 per cent. of sodium bicarbonate and not less than 73 per cent. nor more than 78 per cent. of potassium and sodium tartrate.

Condensed Recipe.

Triturate 30 Gm. sodium bicarbonate with 90 Gm. potassium and sodium tartrate, divide equally and wrap in 12 blue papers. Likewise, divide 26 Gm. powdered tartaric acid into 12 portions wrapping each in a white paper.

For assay of the sodium bicarbonate and of the potassium and sodium tartrate, see Part V.

Remarks.—As mentioned previously, this is the one official powder in which the constituents are divided into special doses, the sodium bicarbonate and Rochelle salt being divided into 12 powders, wrapped in blue papers, while the tartaric acid is wrapped in white papers. In preparing

Seidlitz powders the dividing of the powder is performed by using the so-called Seidlitz powder-cup (Fig. 187); one of the cups is purported to hold the amount of Rochelle salt and sodium bicarbonate mixture, while the smaller cup is supposed to contain the amount of tartaric acid which is directed. These cups are used by taking a large quantity of the powdered substance on a sheet of paper, and filling the cup by pressing into the powdered mass, placing the cup over the powder paper, and emptying on same by a gentle tapping of the cup with a spatula. The use of such cups, however, does not necessarily mean a correct division of the chemicals, as the amount which the cup will hold depends entirely upon the pressure exerted. Some years since an investigator weighed Seidlitz powders obtained from the various stores throughout the country, and found that the weight of the Rochelle salt—sodium bicarbonate mixture put up in blue paper, ranged all the way from 133 grains to 251 grains, while the white paper contained from 30 grains to 56 grains of tartaric acid. (Proper quantities, 155 grains and 33 grains respectively.)

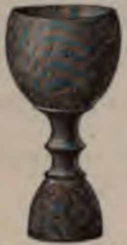
Fig. 187.—Seidlitz powder cup.

For this reason it is wisest to weigh out the contents of each powder, a process more feasible than it seems.

The Rochelle salt—sodium bicarbonate mixture is obtainable in commerce under the name of *Seidlitz mixture*, and that sometimes at a price cheaper than the cost of the separate ingredients. There can be but one explanation of this fact: that such "cheap" Seidlitz mixture contains more than the 25 per cent. of inexpensive sodium bicarbonate directed by the pharmacopœia.

The effervescence occurring on mixing solutions of the contents of the blue and the white papers is due to liberation of carbon dioxide by the chemical action of the tartaric acid on the sodium bicarbonate. Details of this reaction will be found on p. 418.

A difference noted between the average home-made Seidlitz powder and that purchased in the market is the superior keeping quality of acid inclosed in the white papers of the purchased article. Tartaric acid is rather deliquescent, and the home-made "white papers" frequently begin to discolor (the paper wrapper becoming yellow), and not seldom become a moist mass. This trouble can be obviated by thoroughly drying the tartaric acid in an oven or by spreading in the sunshine on a dry day. The tartaric acid so dried will keep as well when wrapped as does that of the commercial Seidlitz powders.

Before leaving the subject of commercial Seidlitz powders reference must be made to an excellent grade found on the market, the subdivision and folding of which are performed on a special machine covered by patents.

This machine—the Doan Seidlitz Powder Machine—is not for sale, the patentee preferring to sell the Seidlitz powders made on the machine, and that at a low price.

Seidlitz powders are much esteemed as purgatives, the effervescence, when administered, masking the taste of Rochelle salts, which is the active ingredient. As is well known, Seidlitz powders are administered by dissolving the contents of the blue and of the white powder in separate glasses one-third filled with water, mixing the two liquids, and drinking while effervescing; *not* by drinking the two liquids one after the other, as has been done more than once, with disastrous results.

Dose.—One set of the two powders.

PULVIS GLYCYRRHIZÆ COMPOSITUS—Compound Powder of Glycyrrhiza

(**Pulv. Glycyrrh. Co.**—Compound Licorice Powder)

Condensed Recipe.

Ingredients.—Powdered senna, 180 Gm.; powdered glycyrrhiza, 236 Gm.; washed sulphur, 80 Gm.; oil of fennel, 4 Gm.; sugar, 500 Gm.

Manipulation.—Triturate the oil with some of the sugar, add the rest of the ingredients, mix by trituration and run through a No. 80 sieve. For details, see U.S.P., p. 345.

Remarks.—Compound powder of glycyrrhiza is what is commonly called "compound licorice powder," and is an excellent remedy for costiveness. Note its ingredients, and that washed, not sublimed, sulphur is employed. A paragraph describing the microscopy of the powder is given in the present pharmacopœia.

Dose.—4 Gm. (60 grains).

PULVIS IPECACUANHÆ ET OPII—Powder of Ipecac and Opium

(**Pulv. Ipecac. et Opii.**—Compound Powder of Ipecac. Dover's Powder
Opii et Ipecacuanhæ pulvis compositus P.I.)

Condensed Recipe.

Triturate 10 Gm. ipecac, in No. 60 powder, 10 Gm. powdered opium and 80 Gm. sugar of milk in No. 30 powder until a fine uniform mixture results.

Remarks.—This is the popular *Dover's powder,* and contains 10 per cent. ipecac, 10 per cent. opium, and 80 per cent. sugar of milk. A microscopic description of the powder is given in the pharmacopœia.

Dose.—500 milligrammes (7½ grains).

PULVIS JALAPÆ COMPOSITUS—Compound Powder of Jalap

(**Pulv. Jalap. Co.**—Pulvis Purgans)

Condensed Recipe.

Triturate together 35 Gm. powdered jalap and 65 Gm. potassium bitartrate and then sift. For details, see U.S.P., p. 346.

Remarks.—This powder, sometimes called *pulvis purgans*, consists of 35 per cent. jalap and 65 per cent. cream of tartar. Its microscopy is given in the pharmacopœia.

Dose.—2 Gm. (30 grains)

PULVIS RHEI COMPOSITUS—Compound Powder of Rhubarb

(**Pulv. Rhei Co.**)

Condensed Recipe.

Triturate 25 Gm. powdered rhubarb with 10 Gm. powdered Jamaica ginger, then add 65 Gm. magnesium oxide, mix by trituration and then sift. For details see U.S.P., p. 347.

Remarks.—Compound powder of rhubarb or *rhubarb and magnesia* is yellow when first prepared, but turns pink on standing, due to the action of alkaline magnesia on the resins found in rhubarb. The pharmacopœial monograph includes the microscopy of the powder.

Dose.—2 grammes (30 grains).

Pulvis Morphinæ Compositus (U.S.P. VIII) or *Tully's powder*, was made by triturating 1.5 Gm. of morphine sulphate, with 33.5 Gm. of precipitated calcium carbonate; then with 32 Gm. of camphor previously pulverized by use of alcohol; and lastly with 33 Gm. of powdered glycyrrhiza. It enjoyed considerable popularity in New England, but under present-day narcotic legislation, its use is discouraged.

Dose.—500 milligrammes (8 grains).

DOSES OF OFFICIAL POWDERS

500 milligrammes (8 grains)	Powder of ipecac, and opium.
1 gramme (15 grains)	Aromatic powder.
2 grammes (30 grains)	Powders of chalk compound, jalap compound, rhubarb compound.
4 grammes (60 grains)	Powder of glycyrrhiza compound.
One set of two powders	Compound effervescing powder.

POWDERS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 100 grammes)	Remarks
Pulvis acetanilidi compositus.	Compound acetanilid powder.	Acetanilid, 70 Gm.; caffeine; sodium bicarbonate.	See p. 697. *Dose.*—300 milligrammes (5 grains).
Pulvis aloes et canellæ.	Hiera picra.	Aloes, 80 Gm.; canella, 20 Gm.	*Dose.*—300 milligrammes (5 grains).
Pulvis antimonialis.	James' powder.	Antimony oxide, 33 Gm.; precipitated calcium phosphate.	*Dose.*—200 milligrammes (3 grains).
Pulvis antisepticus.	Soluble antiseptic powder.	Salicylic acid; phenol, 1 Gm.; eucalyptol; menthol; thymol; zinc sulphate, 125 Gm.; boric acid.	
Pulvis aromaticus rubifaciens.	Rubefacient spice powder.	Clove; Saigon cinnamon; ginger; capsicum.	Moistened with warm diluted alcohol or vinegar, it gives a *spice poultice.*
Pulvis cretæ aromaticus.	Aromatic powder of chalk.	Saigon cinnamon; myristica; clove; cardamom seed; prepared chalk; sugar.	*Dose.*—2 grammes (30 grains).
Pulvis cretæ aromaticus et opii.	Aromatic powder of chalk and opium.	Powdered opium, 2.5 Gm.; aromatic powder of chalk.	*Dose.*—1 gramme (15 grains).
Pulvis gambir compositus.	[Pulvis catechu compositus, N. F. III.]	Gambir; kino; krameria; Saigon cinnamon; myristica.	*Dose.*—1.3 gramme (20 grains).
Pulvis hydrargyri chloridi mitis et jalapæ.	Calomel and jalap.	Mild mercurous chloride; 34 Gm.; jalap.	*Dose.*—650 milligrammes (10 grains).
Pulvis kino et opii compositus.	[Pulvis kino compositus N.F.III.]	Kino; powdered opium, 5 Gm.; Saigon cinnamon.	*Dose.*—1 gramme (15 grains).
Pulvis myricæ compositus.	Composition powder.	Bayberry bark; ginger; capsicum; clove.	*Dose.*—1 gramme (15 grains).
Pulvis pancreatini compositus.	Peptonizing powder.	Pancreatin, 20 Gm.; sodium bicarbonate.	One and one-half grammes is capable of peptonizing 500 mils of fresh milk.
Pulvis rhei et magnesiæ anisatus.	Compound anise powder.	Rhubarb, 35 Gm.; heavy magnesium oxide; anethol. Alcohol to facilitate admixture.	*Dose.*—(for infants), 300 milligrammes (5 grains).
Pulvis talci compositus.	Boro-salicylated powder of talc.	Salicylic and boric acids; talc.	The popular *borated talcum.*

SPECIES

This represents a mixture of drugs, usually of vegetable origin, dispensed either in coarse powder or in a more or less roughly comminuted form. There is no pharmacopœia representative of this class, but the following are included in the National Formulary.

Species Emollientes or *Emollient Cataplasm*, consisting of althæa leaves; mallow leaves; melilot, matricaria and linseed.

Species Laxativæ or *St. Germain Tea*, consisting of senna, elder flowers; fennel; anise; and potassium bitartrate.

Species Pectorales or *Breast Tea*, consisting of althæa; coltsfoot; Russian glycyrrhiza; anise; mullein flowers; orris root.

TRITURATIONS

Triturations were suggested by similar preparations used in homeopathic practice. The pharmacopœia gives a general formula calling for 10 per cent. of the medicinal substance and 90 per cent. of sugar of milk. There is only one official triturate in which the medicating substance is specifically mentioned, namely, *Triturate of Elaterin.*

TRITURATIONES—Triturations

Recipe.

Unless otherwise directed, Triturations are to be prepared according to the following formula:

Recipe.

The Substance, *ten grammes*	10 Gm.
Sugar of Milk, in moderately fine powder, *ninety grammes*	90 Gm.
To make *one hundred grammes*	100 Gm.

Weigh the Substance and the Sugar of Milk separately; then place the Substance, previously reduced, if necessary, to a moderately fine powder, in a mortar; add about an equal measure of Sugar of Milk, mix well by means of a spatula, and triturate the powders thoroughly together. Then add fresh portions of the Sugar of Milk, from time to time, until the whole is added, and continue the trituration after each addition until the Substance is intimately mixed with the Sugar of Milk and reduced to a fine powder.

Remarks.—Note that the sugar of milk must be added little by little.

TRITURATIO ELATERINI—Trituration of Elaterin

(Trit. Elaterin.)

Recipe.

Elaterin, *ten grammes*	10 Gm.
Sugar of Milk, in moderately fine powder, *ninety grammes*	90 Gm.
To make *one hundred grammes*	100 Gm.

Mix them thoroughly by trituration.

Dose.—30 milligrammes (½ grain).

Homeopathic triturates are grouped into the classes "x" or dilutions one in 10; "c" or dilutions one in 100; and "m" or dilutions one in 1000. A dilution "2x" or "xx" is prepared by triturating one part of the drug with 9 parts of the diluent (making an "x" triturate) and then triturating one part of this "x" triturate with nine parts of diluent. Ordinary mortals would consider this "2x" trituration clearly a 1 per cent. preparation, the same as a "c" dilution, which is also certainly a 1 per cent. trituration, but homeopaths insist that the differing manipulation makes the two products quite different. In passing it might be said that homeopathic tinctures "x" and "c" are prepared on a similar theory.

OLEO-SACCHARA

This is a class of unofficial preparations which, as suggested by the name, "oleum" and "saccharum," represents a sugar which has been flavored with some aromatic oil. Such oleo-sacchara or *oil-sugars* are quite popular in Germany, where they are used as diluents in the preparing of many powders. They are made by placing the sugar in a mortar, adding the volatile oil, and triturating until the oil is thoroughly divided by the sugar. The National Formulary gives a general formula for the manufacture of them, directing that they be made by triturating 2 mils of the prescribed volatile oil with 100 grammes of powdered sugar. Those mostly prescribed are the oil-sugar of anise, of fennel, and of peppermint.

ADMINISTRATION OF POWDERS

A medicated powder is usually administered by placing the proper dose, if small, on the tongue, and then swallowing same in a draft of water. In cases of intensely bitter substances, such administration is scarcely again, but the writer fails to see wherein these give better results than a plain paper folded by hand, as directed below.

In discussing the question of the various forms of powder boxes, it is necessary here to say that modern pharmacists use the so-called New York powder box, shown in Fig. 182, slide powder boxes failing to give as good results. Into this New York powder box the powder should be placed upright, as is shown in Fig. 180, *e*, and in folding the powder each should be exactly the same size, and should project from the box to the same height—usually made about $\frac{1}{16}$ inch. The finer grade of the powder box is arranged with a sufficient difference between the height of the shoulder and of the inside of the cover to permit the papers to protrude that distance, the object of having the papers protrude being to facilitate the removing of the papers from the box.

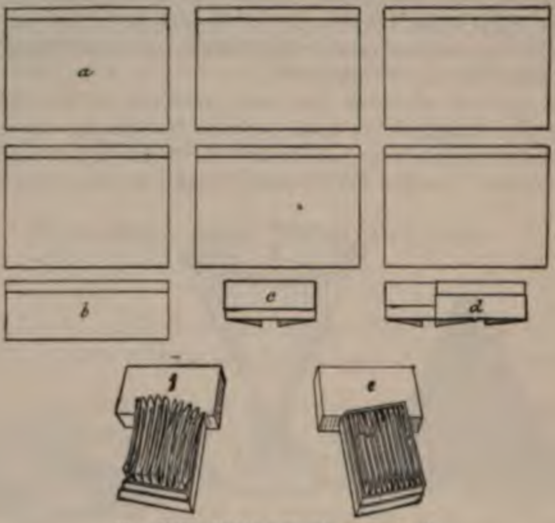

Fig. 180.—Folding powders (see text).

Fig. 181.—Powder folder.

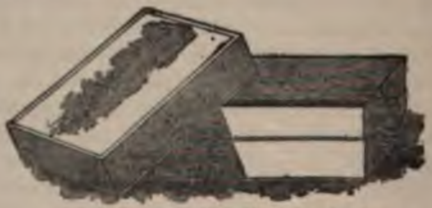

Fig. 182.—New York powder box.

In preparing and successfully folding the paper it is necessary that the paper conform exactly to the dimensions of the box, and in order to aid the pharmacist in this work, the so-called shoulder boxes are made the same length and height, the difference in the size for the different numbers of papers being merely in the width. In purchasing boxes of that kind the pharmacist should procure paper of such size as will make a perfectly neat package; that is, a paper the length of which is a trifle less than double the interior length of the box, while the width of the paper should be a little over twice the height of the box. Having obtained paper of the right dimensions, all that remains to be done is to learn the size which the first flap (Fig. 180, *a*) should be made. This is so regulated that the powder, when folded, with the end where the original flap was made coinciding with the finished folded paper, will make a finished powder of the height suggested above, namely, one which will protrude 1/16 inch from the paper box.

Having folded a paper to conform with the size of the box, it is customary to make the finished powder smooth by rubbing each end down with a spatula. The powders are then gathered up from the counter and piled together with the flaps alternating up and down (Fig. 180, *d*). These precautions are required because it will be seen that the finished powder is thicker where the flap rests than in any other portion of the paper. If the bunch of powders, say 12 to 24, were placed in a box, all in the same position, this slight increase in thickness, multiplied by the number 12 or 24, would make a decided discrepancy in the width of the top and bottom of a bunch of powders; and if such were placed in the box in which they fit snugly, a decided pressure would be exerted at the upper edge, a pressure, in fact, sufficient to cause the springing out of the entire lot of powders when the first paper was removed (Fig. 180, *f*). By alternating the position of the flap up and down the pressure is equalized and no such inconvenience results.

Some pharmacists follow the admirable custom of having their name and address printed on their powder papers in such a position that the printed matter will appear in the center of the folded paper. Such a practice cannot be too strongly recommended, because it affords a highly legitimate method of publicity.

After the powders are neatly folded and placed in the box, the latter is wrapped in an appropriate paper and tied. This leads us to the very important question of the dispensing of packages in elegant form, an art which appears to the writer to be falling into disuse. The first essential in making a successful package is that the paper be of exactly proper proportions, and the writer attributes to the introduction of the roll paper, so largely used in drug-stores at present, and supposed to be unrolled and torn off as required, the lack of care shown in the modern package.

In former days the paper was bought in full sheets and was carefully cut to the size required for the package. Thus, for powder boxes the paper was cut in strips 4 inches wide, and of a length ranging from 6 inches to 8 inches. For pill boxes smaller strips, say 2½ inches wide, were employed. The paper for 1-ounce bottles was 6 by 6 inches, for 2- and 3-ounce bottles was 7 by 8½ inches; for 4- and 6-ounce bottles was 8½ by 11 inches; for 8-ounce bottles was 11 by 11 inches; while for pint bottles it was 12 by 12 inches. Of the papers so cut, the one for 6-ounce bottles usually sufficed for the careful wrapping of 1 to 2 ounces of an herb, and from 4 to 8 ounces of a chemical; while the larger sized papers would be used for proportionately larger quantities. The criticism that might be raised in regard to taking pains in making packages is the time which is required. As far as the wrapping of a powder or pill box or of a bottle, no more time is required for wrapping it carefully than is required to do the same work carelessly, and as for the wrapping of solid substances, it is recommended that the pharmacist follow the custom of old-time druggists of keeping on hand a sufficient stock of packages already wrapped, which can be handed out when demanded. In the author's experience, he kept on hand packages of almost everything for which there was at least one demand a week. Of those substances for which there was a very slight demand, only one package was prepared and kept in the container, and when this was sold, another package was made at the first leisure moment. In this way the pharmacist, especially when by himself in a store, can facilitate dispensing to an enormous extent, because much time is consumed in wrapping packages. Details of making a neat package can be best given accompanied by the following illustrations:

Wrapping a pill box: Take the strip of paper, place the pill box thereon, and bring up the two ends, and fold over into a crease, as is shown in Fig. 183, *a*. The paper should be made of such a size that a second crease about the size of the first one will bring the paper perfectly firmly around the edge of the pill box, as shown in *b*. The paper should then be of sufficient width so that when the edges are folded down in the flap, there will be bulging pieces of paper to be cut off. In the writer's experience, he preferred folding the open edges down to the folded flaps, as shown in *c*, because when so done the tying can be done by simply passing the string two or three times around the edge of the box, as is shown in *d*. Some pharmacists prefer to bring the edges down, as is shown in *e*, when the string must be placed, not merely around the edges, but around the edges of the box, as is shown in *f*. In place of twine, elastic bands are now used, and have much to commend themselves.

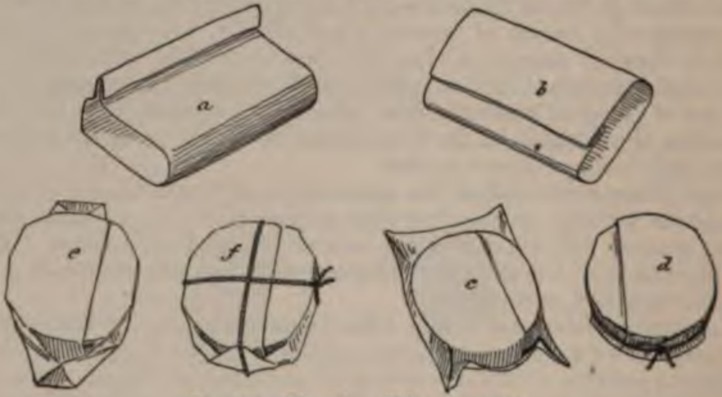

Fig. 183.—Wrapping pill box (see text).

In wrapping a powder box the procedure is similar to that of a pill box, as shown in the various stages in Fig. 184, *a* and *b*. The flaps are folded either as shown in *c* or *d*, and for the same reason as explained in the case of the pill boxes.

In wrapping bottles the mode of procedure is, first, to fold the crease, as shown in Fig. 185, *a*, and, as in the case of the powder and pill boxes, the paper should be of such a size that the second fold will bring the paper snugly around the bottle, as shown in *b*. The open edge at the base of the bottle is then folded in neat flaps, while the paper around the neck should be creased, as shown in *c*.

This done, the bottle is wrapped with string down and back, and finally wound tightly around the neck, as is shown in *d*.

In folding packages the paper is first folded with the crease, as shown in Fig. 186, *a*. This crease is then bent, very great care being required to make it exactly equal the whole length of the package, as shown in *b*. One of the open ends is then temporarily folded, as shown in *c*, while the other end is carefully folded away from the flap, as shown in *d*. This being done, it is then turned downward, the temporary folding of the other end reopened, and refolded exactly as the other end, the finished package is then wrapped with a string, both across its length and width,

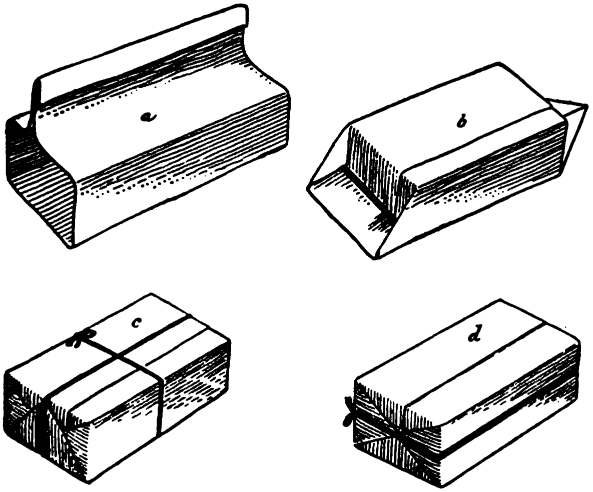

Fig. 184.—Wrapping powder box (see text).

as shown in *e*, although for this purpose a rubber band is frequently substituted.

The folding of solids in packages, as just mentioned, is becoming obsolete, due to the introduction of boxes for holding solid substances at prices justifying their free distribution by the druggist.

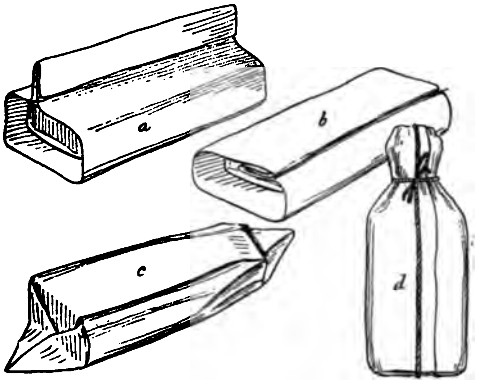

Fig. 185.—Wrapping bottle (see text).

Such boxes should be wrapped with paper in a manner similar to the smaller powder boxes, and the use of such boxes is growing very popular because of the convenience of keeping drugs in such containers. It might be here stated that all packages of drugs and chemicals wrapped in the style above given should be neatly labeled.

As to the choice of wrapping-paper, the writer uses plain white paper in preference to the gaudily colored papers so much in vogue in modern

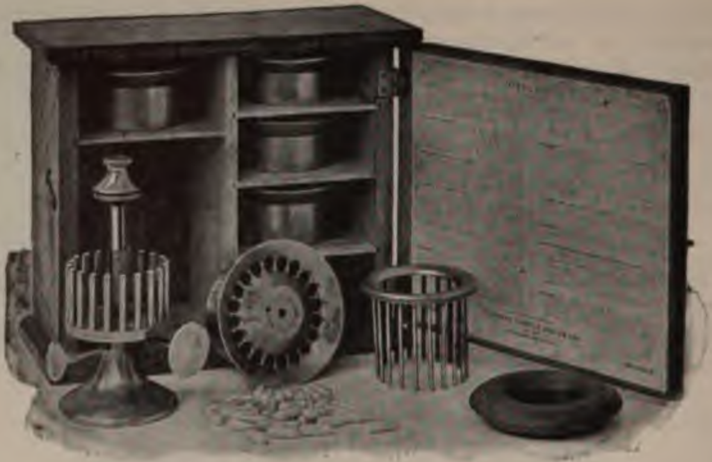

Fig. 197.—The Eastman capsule filler.

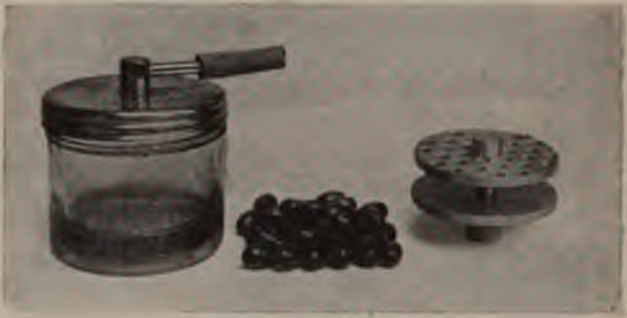

Fig. 198.—Lascoff capsule filler.

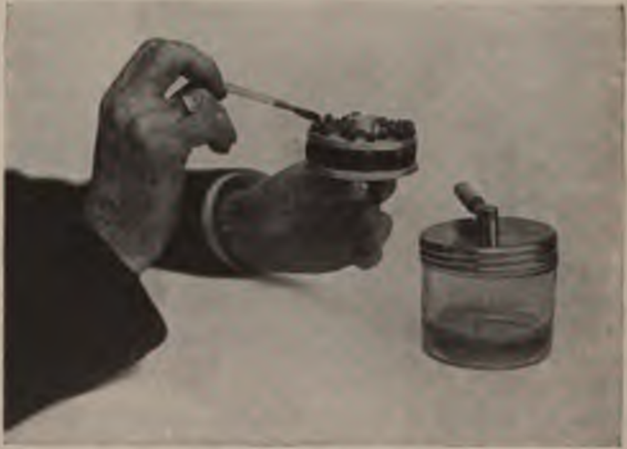

Fig. 199.—Lascoff capsule filler.

SPECIAL NOTES ON OFFICIAL POWDERS

PULVIS AROMATICUS—Aromatic Powder

(Pulv. Arom.)

Condensed Recipe.

Ingredients—Saigon cinnamon and Jamaica ginger, of each, 35 Gm.; cardamom seed and myristica (freshly grated), of each, 15 Gm.

Manipulation.—Triturate the cardamom and nutmeg, with a portion of the cinnamon and then with the rest of the ingredients.

Remarks.—This consists of cinnamon, ginger, cardamom, and nutmeg. The present pharmacopœia directs the use of cardamom seed, deprived of pericarps (the chaffy wall of the ovary constituting the so-called "hull"). This is to be crushed and then triturated to a fine powder with nutmeg and a little cinnamon, blended with finely powdered ginger and cinnamon. Both the cardamom and nutmeg are very unstable in the powdered form; hence the whole drugs are to be powdered in the process of preparation.

It is to be noted that the present pharmacopœia provides a paragraph describing the microscopy of this powder.

Aromatic powder is used chiefly to flavor other powdered substances, although it is of some value for relieving flatulence.

Dose.—1 Gm. (15 grains).

PULVIS CRETÆ COMPOSITUS—Compound Chalk Powder

(Pulv. Cret. Co.)

Condensed Recipe.

Ingredients.—Prepared chalk, 30 Gm.; powdered acacia, 20 Gm.; powdered sugar, 50 Gm.

Manipulation.—Mix by simple trituration and sift. For details, see U.S.P.

Remarks.—This is the chief constituent of *chalk mixture* (p. 257), and is official for that reason alone.

Note that it is made from prepared chalk, not from precipitated chalk, for reasons given on p. 471.

Dose.—2 Gm. (30 grains).

PULVIS EFFERVESCENS COMPOSITUS—Compound Effervescing Powder

(Pulv. Eff. Co.—Seidlitz Powder)

The weight of a mixture in a blue paper is not less than 9.5 Gm. nor more than 10.5 Gm. and contains not less than 23 per cent. nor more than 27 per cent. of sodium bicarbonate and not less than 73 per cent. nor more than 78 per cent. of potassium and sodium tartrate.

Condensed Recipe.

Triturate 30 Gm. sodium bicarbonate with 90 Gm. potassium and sodium tartrate, divide equally and wrap in 12 blue papers. Likewise, divide 26 Gm. powdered tartaric acid into 12 portions wrapping each in a white paper.

For assay of the sodium bicarbonate and of the potassium and sodium tartrate, see Part V.

Remarks.—As mentioned previously, this is the one official powder in which the constituents are divided into special doses, the sodium bicarbonate and Rochelle salt being divided into 12 powders, wrapped in blue papers, while the tartaric acid is wrapped in white papers. In preparing

Seidlitz powders the dividing of the powder is performed by using the so-called Seidlitz powder-cup (Fig. 187); one of the cups is purported to hold the amount of Rochelle salt and sodium bicarbonate mixture, while the smaller cup is supposed to contain the amount of tartaric acid which is directed. These cups are used by taking a large quantity of the powdered substance on a sheet of paper, and filling the cup by pressing into the powdered mass, placing the cup over the powder paper, and emptying on same by a gentle tapping of the cup with a spatula. The use of such cups, however, does not necessarily mean a correct division of the chemicals, as the amount which the cup will hold depends entirely upon the pressure exerted. Some years since an investigator weighed Seidlitz powders obtained from the various stores throughout the country, and found that the weight of the Rochelle salt—sodium bicarbonate mixture put up in blue paper, ranged all the way from 133 grains to 251 grains, while the white paper contained from 30 grains to 56 grains of tartaric acid. (Proper quantities, 155 grains and 33 grains respectively.)

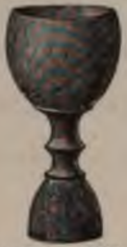
Fig. 187.—Seidlitz powder cup.

For this reason it is wisest to weigh out the contents of each powder, a process more feasible than it seems.

The Rochelle salt—sodium bicarbonate mixture is obtainable in commerce under the name of *Seidlitz mixture*, and that sometimes at a price cheaper than the cost of the separate ingredients. There can be but one explanation of this fact: that such "cheap" Seidlitz mixture contains more than the 25 per cent. of inexpensive sodium bicarbonate directed by the pharmacopœia.

The effervescence occurring on mixing solutions of the contents of the blue and the white papers is due to liberation of carbon dioxide by the chemical action of the tartaric acid on the sodium bicarbonate. Details of this reaction will be found on p. 418.

A difference noted between the average home-made Seidlitz powder and that purchased in the market is the superior keeping quality of acid inclosed in the white papers of the purchased article. Tartaric acid is rather deliquescent, and the home-made "white papers" frequently begin to discolor (the paper wrapper becoming yellow), and not seldom become a moist mass. This trouble can be obviated by thoroughly drying the tartaric acid in an oven or by spreading in the sunshine on a dry day. The tartaric acid so dried will keep as well when wrapped as does that of the commercial Seidlitz powders.

Before leaving the subject of commercial Seidlitz powders reference must be made to an excellent grade found on the market, the subdivision and folding of which are performed on a special machine covered by patents.

This machine—the Doan Seidlitz Powder Machine—is not for sale, the patentee preferring to sell the Seidlitz powders made on the machine, and that at a low price.

Seidlitz powders are much esteemed as purgatives, the effervescence, when administered, masking the taste of Rochelle salts, which is the active ingredient. As is well known, Seidlitz powders are administered by dissolving the contents of the blue and of the white powder in separate glasses one-third filled with water, mixing the two liquids, and drinking while effervescing; *not* by drinking the two liquids one after the other, as has been done more than once, with disastrous results.

Dose.—One set of the two powders.

PULVIS GLYCYRRHIZÆ COMPOSITUS—Compound Powder of Glycyrrhiza

(**Pulv. Glycyrrh. Co.**—Compound Licorice Powder)

Condensed Recipe.

Ingredients.—Powdered senna, 180 Gm.; powdered glycyrrhiza, 236 Gm.; washed sulphur, 80 Gm.; oil of fennel, 4 Gm.; sugar, 500 Gm.

Manipulation.—Triturate the oil with some of the sugar, add the rest of the ingredients, mix by trituration and run through a No. 80 sieve. For details, see U.S.P., p. 345.

Remarks.—Compound powder of glycyrrhiza is what is commonly called "compound licorice powder," and is an excellent remedy for costiveness. Note its ingredients, and that washed, not sublimed, sulphur is employed. A paragraph describing the microscopy of the powder is given in the present pharmacopœia.

Dose.—4 Gm. (60 grains).

PULVIS IPECACUANHÆ ET OPII—Powder of Ipecac and Opium

(**Pulv. Ipecac. et Opii.**—Compound Powder of Ipecac. Dover's Powder
Opii et Ipecacuanhæ pulvis compositus P.I.)

Condensed Recipe.

Triturate 10 Gm. ipecac, in No. 60 powder, 10 Gm. powdered opium and 80 Gm. sugar of milk in No. 30 powder until a fine uniform mixture results.

Remarks.—This is the popular *Dover's powder*, and contains 10 per cent. ipecac, 10 per cent. opium, and 80 per cent. sugar of milk. A microscopic description of the powder is given in the pharmacopœia.

Dose.—500 milligrammes (7½ grains).

PULVIS JALAPÆ COMPOSITUS—Compound Powder of Jalap

(**Pulv. Jalap. Co.**—Pulvis Purgans)

Condensed Recipe.

Triturate together 35 Gm. powdered jalap and 65 Gm. potassium bitartrate and then sift. For details, see U.S.P., p. 346.

Remarks.—This powder, sometimes called *pulvis purgans*, consists of 35 per cent. jalap and 65 per cent. cream of tartar. Its microscopy is given in the pharmacopœia.

Dose.—2 Gm. (30 grains)

PULVIS RHEI COMPOSITUS—Compound Powder of Rhubarb

(**Pulv. Rhei Co.**)

Condensed Recipe.

Triturate 25 Gm. powdered rhubarb with 10 Gm. powdered Jamaica ginger, then add 65 Gm. magnesium oxide, mix by trituration and then sift. For details see U.S.P., p. 347.

Remarks.—Compound powder of rhubarb or *rhubarb and magnesia* is yellow when first prepared, but turns pink on standing, due to the action of alkaline magnesia on the resins found in rhubarb. The pharmacopœial monograph includes the microscopy of the powder.

Dose.—2 grammes (30 grains).

Pulvis Morphinæ Compositus (U.S.P. VIII) or *Tully's powder*, was made by triturating 1.5 Gm. of morphine sulphate, with 33.5 Gm. of precipitated calcium carbonate; then with 32 Gm. of camphor previously pulverized by use of alcohol; and lastly with 33 Gm. of powdered glycyrrhiza. It enjoyed considerable popularity in New England, but under present-day narcotic legislation, its use is discouraged.

Dose.—500 milligrammes (8 grains).

the pill mass should be *soluble;* that is, on being introduced into the stomach it should disintegrate within a reasonable time.

In making a pill mass we usually have recourse to the excipient, and this excipient is different from what we usually and narrowly conceive it to be. Ordinarily, we consider it as a sticky mass with which we "paste" up a solid into pill form. In the broad sense, however, the term applies with equal force to those substances with which we solidify liquids into pill form—like the magnesia used to solidify copaiba.

Among the excipients used in making pharmaceutic pills are *water, sulphuric acid, syrup, syrup of acacia, mucilage of acacia, glycerin, glucose, honey, glycerite of tragacanth, extract of gentian, bread-crumbs, soap, resin cerate, petroleum mass.*

Water is used for making pills only when the pill mass contains some ingredient, which, when moistened, forms an excipient. Thus, if the mixed powder contains gummy substances, say, acacia or soap, the addition of a few drops of water and working up of the mixture will result in a pliable mass. In such cases, however, the action is the same as if mucilage of acacia or soap and water were used.

Sulphuric acid, either concentrated or in the form of aromatic sulphuric acid, is sometimes used as an excipient in the manufacture of pills of quinine sulphate. When the acid is added to this chemical it forms a soft and comparatively plastic mass of quinine bisulphate, which can be divided into pills if the mass is worked rapidly. Such method of dispensing quinine sulphate was very largely employed in the South in previous years, but is now falling into disuse.

Syrup is used for certain forms of pills, but is scarcely efficient unless there is present in the mixed powder some gummy substance.

Syrup of acacia would be an excellent excipient were it not for the fact that the finished product, when dry, is usually so hard as seriously to impair its solubility.

Mucilage of acacia has the same advantages and disadvantages of syrup of acacia.

Glycerin is rather extensively used in making the pills of the alkaloids, such as quinine sulphate. It has never been found satisfactory in the hands of the writer by reason of its lack of adhesiveness. One advantage of glycerin as an excipient is that its hygroscopic character keeps the pill soft and thus soluble for quite a while.

Glucose is very largely used as an excipient, being both adhesive and plastic.

Honey is sometimes used, but it has no advantage over glucose, of which it largely consists, and possesses the very decided disadvantage of imparting to the mass a slightly brownish tint.

Glycerite of tragacanth, consisting of three drachms of powdered tragacanth, three fluidounces of glycerin, and one-half fluidounce of water, has always been the writer's favorite excipient, it yielding a mass both plastic and adhesive and firm. Similar results can be gained by the use of the official *glycerite of starch.*

Extract of gentian is frequently prescribed as an excipient and is valuable in tonic pills. *It should, however, never be used as an excipient unless so directed by the physician.* In the first place, gentian has marked medicinal properties, and the pharmacist should never add to a prescription any medicine other than that directed in the recipe. Another point is that it possesses a brownish tint, and in making pills of colorless substances the mass will be discolored, a defect that the careful pharmacist will never permit.

Bread-crumb is used for holding liquids, such as volatile oils, in the plastic form. Thus, were pill of croton oil directed, the crumb of bread would be indicated. *Magnesia* is used in a similar way with the liquids on which it exerts a solidifying action. Thus, copaiba directed in pills should be massed by means of magnesia (see above), and this is also true of Venice turpentine.

Soap is used in persuading resinous substances to assume the plastic form. Thus, all official pills containing aloes are made plastic and adhesive by the addition of soap. This explains its presence in compound extract of colocynth; and it might here be stated that an attempt to make compound cathartic pills with the simple extract of colocynth instead of the compound extract proves a failure by reason of the absence of soap.

The *resin cerate* and *petroleum mass* are used as excipients for pills containing easily oxidizable substances, such as potassium permanganate, chromic acid, and silver oxide. For this purpose a petroleum mass consisting of kaolin, 3 parts; paraffin, 1 part; and vaselin, 3 parts, can be used to advantage.

The following drugs, frequently prescribed in pill form, require special manipulation:

Creosote, or *guaiacol*, or other oily liquids may be massed by diluting with an absorbent powder like glycyrrhiza or althæa, and massing with ordinary excipient. From such pills, however, the oils gradually ooze out, and the best way is to inclose the mass in capsules. T. M. Pratt found that by rubbing the oil with acacia, then with the diluting powders, and then with excipient, the oil is partially emulsified and the "sweating" is prevented.

Heavy salts, like *bismuth subnitrate*, *calomel*, or *sodium bicarbonate*, can be massed with glycerite of tragacanth. If desirable, a small quantity of powdered elm bark may be added.

Bismuth subnitrate and *sodium bicarbonate* when massed together swell and disintegrate, due to liberation of carbon dioxide. The powders should be moistened first with water and let stand, until the reaction is over (one to three hours); then massed with glycerite of tragacanth.

Potassium iodide can be massed by adding to each 0.20 Gm. of the salt, starch 0.04 Gm.; powdered acacia, 0.08 Gm.; calcined magnesia, 0.10 Gm.; the excipient used being glycerin, 20 parts; syrup, 50 parts and alcohol, 30 parts.

The making of a pill mass is performed by thoroughly blending the powders by triturating in a mortar, adding the necessary quantity of excipient, and working the mixture with a pestle until a plastic mass results. (For details of the process see Part VII.) The making of a successful pill mass is merely a matter of practice, and depends largely on the adding of the exact quantity of excipient when first starting the kneading. This really explains the psychology of the "favorite excipient," it being the writer's experience that the druggist holds as firmly to his pet excipient as he does to his political creed. The reason for this is that the individual has mastered the peculiarities of this special excipient, and such excipient is in his case the best that he can use, inasmuch as he has learned by intuition the exact amount required for each pill mass. Hence, unless the favorite excipient possesses marked defects, such as rendering the pills insoluble or the like, or bringing into the mass a medicinal effect not expected by physicians, no attempt should be made to win a pharmacist from his favorite excipient.

Dividing the Mass.—When the mass has become sufficiently worked, that is, when the pressing of the pestle is sufficient to enable the mass to be rolled from the side of the mortar, it is then rolled into cylinders and divided either on the pill tile or by means of the pill cutter. The details of the use of a pill tile, both in working up the mass and also in dividing the same, is fully described in Part VII, and it is necessary here only to insert a picture of the apparatus (Fig. 200), which is made of porcelain, with the painted graduations burnt in during the process of glazing. In rolling out the pill mass into cylinders a spatula is used or, what is preferable, a flat board shaped like a paddle. As mentioned in Part VII, the pill tile should be carefully dusted with the appropriate dusting-powder.

As to pill-cutting machines, these usually consist of brass-bound walnut boards, holding at one end a brass mold, which is divided into a definite number of perfectly uniform hemispheric concave grooves. Working on this is a cutter, which consists of a narrow piece of walnut, provided at each end with stable handles, having attached to one side a brass plate with hemispheric grooves, exactly fitting those on the other part of the apparatus. A set of brass rollers, worked on the brass bands of the sides of the plate, completes the cutter (Fig. 201). In using such a machine the cylinder is placed on the wooden part of the board and rolled out, preferably with a wooden paddle, rather than with the back of cutter, to a length including the number of grooves representing the number of pills desired. The cylindric pill mass is then placed on the grooves of the machine, and the grooves of the cutters are then brought down upon it, thus dividing the cylinder into the number of segments desired. If the diameter of the cylinder exactly coincides with the diameter of the grooves, these segments can be rolled into pills by a gentle rolling of the two plates on each other, and in this way the machine does not merely cut the cylinder, but also rolls them into pills. Special pill machines are on the market in which the grooved plates are removable from the boards and also from the cutter; and with each machine goes a series of these plates coinciding with the average size of pills. Thus, there is one set of plates for 1-grain pills, 2-grain pills, and 3-grain pills, and one for 5-grain pills. Such machines, however, are rather expensive, and in the average pharmacy the machine is used for cutting rather than for rolling the pills. In purchasing a machine the pharmacist is advised to secure one with plates having at least 36 grooves; the smaller machines, cutting only 12 pills, cost but little less than the wider ones and are not so useful.

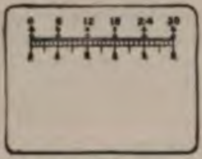

Fig. 200.—Pill tile.

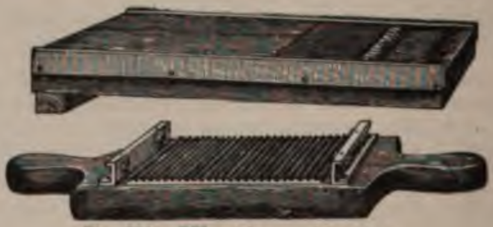

Fig. 201.—Pill-cutting machine.

Rolling the Pills.—The cut segments, unless rolled in the machines, are taken up between the finger and the thumb and rolled by means of a rotating movement until perfectly spheric. The finishing touches are performed, especially when the mass is hard and difficult to roll between the finger and the thumb, by placing the partially rolled pills on the board of the pill machine, dusting fairly liberally with the dusting-powder, covering with a wooden pill roller (Fig. 202), which is then held firmly by the hand and moved over the board, either in the form of circles or in figure eights, the friction between the roller and the board being sufficient to smooth the pills into spheric forms, providing the mass is sufficiently firm. If the pills are soft the pressure exerted must be very gentle, and it is usually advisable, in securing successfully rolled pills, that the depth of the roller be exactly the same as the height of the finished pill. To accomplish this, however, it would be necessary to have a set of rollers of different depths, and this is rarely the case in the average pharmacy.

As mentioned in Part VII, both in rolling and dispensing the pills they are dusted with powder, designed to prevent the pills from sticking together. It is considered good pharmacy to dust the colorless pills with a white powder, such as a finely powdered starch; while those which are of a dark color are usually dusted with lycopodium powder; glycyrrhiza is used as a dusting-powder, especially in Germany, but is not considered so satisfactory as lycopodium. In dispensing ready-made coated pills no dusting-powder should be used.

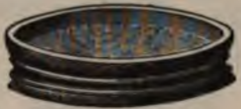
Fig. 202.—Pill roller.

The finished pills are usually dispensed in round boxes, commercially called pill boxes. Of late years square, shouldered boxes have come into use among the better pharmacies, and are very satisfactory, although the increased cost over the round pill boxes renders their use less popular than the latter.

The wrapping of a pill box has already been described on p. 288. Pills are now made on an enormous scale by machinery, the finest type of which is that made by Arthur Colton, of Detroit. The outfit consists of a kneading machine, which prepares the mass; a rolling machine, in which lumps of the mass are rolled into cylinders; a cutting and finishing machine, which cuts the cylinder into the individual pills and rolls them until spheric or ovoid, as desired. The pills are then dried and coated.

Friable pills are a class introduced by Dr. Upjohn in 1885, and were much vaunted as pills made without excipient and, therefore, capable of disintegrating as soon as the coating is dissolved. The process of manufacturing these pills is exceedingly clever, consisting of placing the mixed powder containing the medicinal substances in a cylindric pill-coating machine (see p. 308), introducing therein a lot of sugar pellets, about ¼ grain in size and gradually spraying water therein as the coater revolves. As these pellets are rolled in the moistened powder they gradually collect the powder in a way quite similar to making a large snowball by rolling a small one in damp snow. The rotation of the pills is continued until most of the pills are of the desired size. They are then removed from the machine, and are sifted through special colanders with orifices of exactly the size of the pill desired. Thus, in making quinine pills by this method colanders are provided with holes which have been carefully determined as representing 1-grain, 2-grain, 3-grain, and 5-grain pills. Placing the pills of the various sizes into, say, the 3-grain colander, those remaining on the colander weigh over three grains, while those falling through are from 1 to 3 grains. By placing those which have fallen through on a 2-grain colander, those smaller than 3 grains pass through, and at last the desired size is obtained. The pills which are smaller than any of the required sizes are returned to the machine, and rotation continued until brought up to the weight desired. The finished pills are rapidly coated with either sugar or gelatin, and are thus dispensed.

C. S. N. Hallberg called attention to the fact that the friable pills presented the same objection as is made to most of the commercial pills—that is, in order to obtain a pill the coating of which will not discolor, the rolled pill is first coated with a layer of plaster of Paris and then with the proper coating.

Coating of Pills.—As mentioned above, the fresh pills prepared by the pharmacist are coated merely by dusting with some powder, say, starch or lycopodium. A century ago attempts were made to present the pill in a more attractive appearance by use of special and permanent coating; the first material used for this purpose was French chalk, which is a variety of powdered soap-stone (silicate of magnesium). The coating of pills by this process—called *pearl coating*—consists of placing the finished pill in a small dish containing alcoholic or ethereal solution of balsam of tolu, thus coating it with enough of the balsam to be thinly varnished. While this varnish is still wet they are thrown into French chalk, the mixture of pills and chalk placed in a small sieve, and an excess of powder removed by sifting. The pills are then placed in a hollow sphere (Fig. 203), the two hemispheres of which were united by means of a screw-joint. The pills were rotated in this ball by vigorous agitation, and in this way the excess of chalk was thrown off and that remaining was worked into a smooth, pearly coating. The process of silver or gold coating pills was performed in a manner quite similar, the pills were first varnished, as in the pearl coating, then placed in the hollow globe, containing sheets of gold- or silver-foil. By rotating the pills the foil adheres to the same, and by vigorous agitation of the globe the coating became uniform and polished.

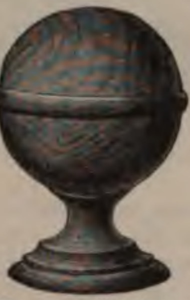
Fig. 203.—Pill silverer.

Sugar coating was first introduced by confectioners for the purpose of coating almonds. Its use in this way was so successful that there soon arose a demand for pills coated in the same manner, and with this demand began the industry of the manufacture of sugar-coated pills.

The process of sugar coating pills is performed in spheric pans, continuously rotated by means of a central axis by means of steam power. This pan is usually of copper, and is jacketed so that it can be kept uniformly warm with steam. Within the pan a quantity of syrup, almost ready to crystallize, is placed, and when the walls of the pan have become smeared with the syrup, the rounded, dried, uncoated pills are placed therein. As the apparatus rotates, the heat gradually drives off the water from the syrup, with the resulting formation of the layers of sugar on the pills, the process being continued until each pill is uniformly coated with a hard, white, sugary layer. The coated pills are then taken from the apparatus and are rotated in a similar apparatus containing paraffin and lined with rough canvas, when the friction, plus the wax, produces a fine polish.

As mentioned above, the great objection to the sugar-coated pills is the fact that, in order that the coating of pills made of dark constituents does not discolor, it is necessary to coat the pill with a layer of plaster-of-Paris, which certainly does not increase the rapid solubility of the pill.

Of late, manufacturers have been placing on the market chocolate and pink-coated pills. These are prepared in a manner similar to the white-coated pills, with the exception that in the first case a small amount of chocolate is added to the syrup, while in the case of the pink, carmine coloring is added to the syrup.

The sugar coating of pills is a process which cannot be done by the retail pharmacist, the coating pan requiring steam power and steam heat. Several schemes of hand-made sugar-coated pills have been suggested, but when tried by the writer, have never yielded satisfactory results. As the public is now demanding sugar-coated pills, the art of pill-making is rapidly falling into disuse.

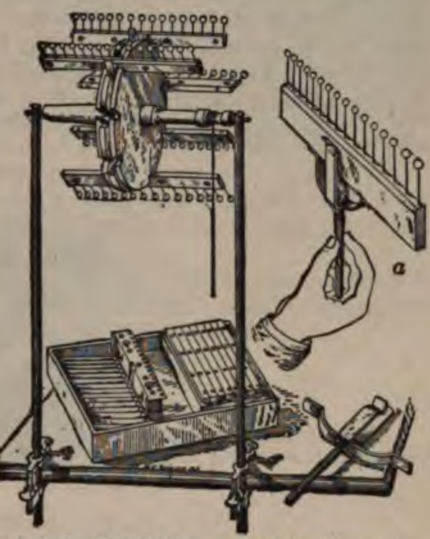

Fig. 204.—Patch's improved gelatin pill-coater.

Gelatin coating of pills is done just as well by the retail pharmacist as by the manufacturer, and several varieties of gelatin-coating apparatus are now on the market at moderate prices. Essentially, the process consists of impaling each pill on a long needle and dipping the same into a solution of gelatin of the proper consistence. Such a solution consists of gelatin, 200; macerate with cold water, 200; then add hot water, 640; mucilage, 300 (acacia, 102; water, 300); syrup, 400; glycerin, 60. Dissolve by gentle heat and then strain. The apparatus devised for the purpose consists merely in carrying out this idea with greater expedition, the needles being arranged in groups, which make it convenient to handle considerable quantities of pills at one time, and also to dry them easily.

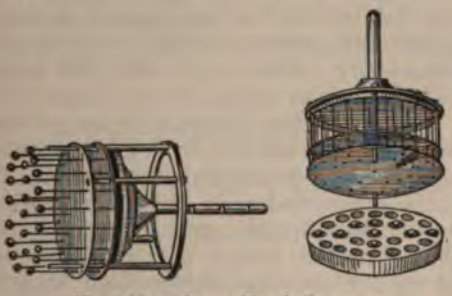

Fig. 205.—Maynard's gelatin coater.

Two types of gelatin-coating machines are shown in Figs. 204, 205—the Patch machine and the Maynard machine. In the Patch machine the pills are impaled on the teeth of a comb (*a*); the ingenious part of the process is the drying apparatus, which consists of a wheel holding seven such combs, rotating by means of a string (Fig. 204). In the Maynard machine the needles are grouped on a circular disk, corresponding to the depressions in a circular plate which holds the pills while being impaled. The impaled pills are then dipped into the gelatin solution and are dried by rapidly whirling the disk holding them. When the coating is dry, the pills are loosened from the pins by pressing down a special plate in the twirler (Fig. 205).

The manufacture of pills by this process yields an admirable gelatin coating, which, however, has been criticized by reason of the fact that they contain minute orifices—the pinholes. The presence of this pinhole can in no way interfere with the finished pill, and, if anything, will aid in solubility. But this so-called defect has been seized as an opportunity of manufacturing a pill in which the pinhole would be avoided. This is accomplished by means of the Russell gelatin-coating machine.

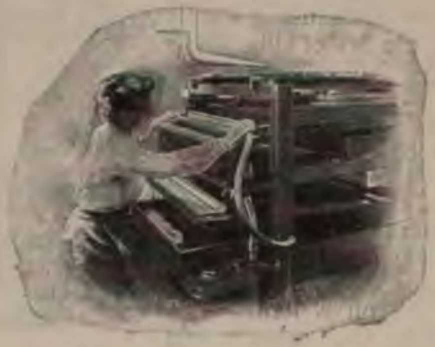

Fig. 206.—Russell's gelatin coater.

In this ingenious apparatus the pills, instead of being impaled on pins, are held on the end of minute tubes by means of suction. As shown in Fig. 206, the apparatus consists of a hollow steel plate, the flat sides of which are provided with a series of minute tubes. Suction is applied by means of flexible tubing connecting the plate with an air-pump, when the plate is held over a disk containing hemispheric depressions exactly corresponding in number and position to the tubes in the plate. In each depression is mechanically rolled a pill, and the moment the plate is placed over the pills, they are sucked to the ends of the tubes and are thus firmly held. The pill is then dipped into the gelatin solution, coated half way, turned upward, and allowed to dry, the stop-cock at the end of the plate being closed, thus continuing the vacuum in the plate even after the rubber tube connected with the air-pump has been removed. The tubing is then connected with another plate of the same kind, and another set of pills are coated; and in this way the coating is continued until a number of such plates have been filled with the pills and half coated. The plates containing half-coated pills have, in the meanwhile, been placed on a special apparatus consisting of an endless chain carrier, and have been gradually moving toward the other end of the frame, where they are taken charge of by the second operator, who transfers the pills to a second plate by suction in such a way that they are grasped by their coated ends, which are now dry. The pills are then dipped again into the gelatin solution, and the second half of the coating thus completed. The pills are then placed once more on the endless chain carrier, and by the time they reach the other end of the frame they are thoroughly coated and perfectly dry (Fig. 206).

Enteric pills are a special form of pill which are intended to pass through the acid juices of the stomach without dissolving, to dissolve in the alkaline juices of the small intestine. To accomplish this result it is necessary to coat such pills with a material which dissolves in alkalis and not in acids, and for this purpose keratin or salol is employed. Keratin is a commercial product obtained from goose-quills, and the constituent of all horny matter. In using it as a pill coating keratin is dissolved in ammoniacal solution, in alcohol, or in glacial acetic acid. The pill mass must be made with butter of cacao, or oil of sweet almond, and must be free from moisture, and then rotated in the keratin solution until thoroughly moistened, taken out and dried, and the coating repeated three or four times. By reason of the complexity of thus coating pills with keratin it has been suggested to coat with salol by dipping the pills into the melted chemical. The pinhole in both cases of coating must be closed by the addition of a small quantity of coating material. Puckner has shown that practically all commercial keratins dissolve in the stomach hence are useless for enteric pill coating.

Before proceeding to a consideration of the official pills, attention should be called to the admirable monograph on pills found in the present edition of the National Formulary.

TABLE OF OFFICIAL PILLS

Process	*Excipient*	*Galenic Preparations*	*Chemical Preparations*
Massing and rolling.			
Uncoated.	Water.	Compound pills of rhubarb.	
	Diluted alcohol.	Compound cathartic pills.	
	Soap and water.	Pills of aloes. Pills of asafetida.	
	Tragacanth, glycerin, and water.		Pills of ferrous carbonate.
Coated pills.	Acacia and water.		Pills of ferrous iodide.
	Acacia, glycerin, and water.	Pills of phosphorus.	

SPECIAL NOTES ON OFFICIAL PILLS

PILULÆ ALOES—Pills of Aloes

(Pil. Aloes)

Condensed Recipe.

Ingredients.—Aloes, 13 Gm.; powdered soap, 13 Gm.; water, enough.

Manipulation.—Triturate the powders, mass with water and divide into 100 pills.

Dose.—Two pills.

PILULÆ ASAFŒTIDÆ—Pills of Asafetida

(Pil. Asafœt.)

Condensed Recipe.

Ingredients.—Asafetida, 20 Gm.; powdered soap, 6 Gm.; water, enough.

Manipulation.—Mass the solids with the water and divide into 100 pills.

Dose.—Two pills.

PILULÆ CATHARTICÆ COMPOSITÆ—Compound Cathartic Pills

(Pil. Cathart. Co.)

Recipe and full details of manufacture of these pills will be found in Part VII.

Remarks.—These pills contain compound extract of colocynth, mild mercurous chloride (calomel), resin of jalap, and gamboge, made into a mass with diluted alcohol.

Dose.—Two pills.

PILULÆ FERRI CARBONATIS—Pills of Ferrous Carbonate

These pills, commonly called *Blaud's pills*, depending for their activity upon a chemical action, can best be discussed among the iron preparations in Part III.

PILULÆ FERRI IODIDI—Pills of Ferrous Iodide

These pills are one of the two official pills directed to be coated with balsam of tolu to prevent oxidation.

Since their manufacture depends on a chemical action, they will be discussed among the iron preparations in Part III.

PILULÆ PHOSPHORI—Pills of Phosphorus

(Pil. Phosphor.)

Recipe and details of manipulation will be found in Part VII.

Remarks.—Each pill contains about $\frac{1}{100}$ grain of phosphorus, made by mixing a chloroformic solution of phosphorus with althæa and acacia, adding the excipient, glycerin and water, and rapidly massing, cutting, and rolling into pills. The massing must be done rapidly, as phosphorus long exposed to air takes fire spontaneously. The ignition is due to the oxidation of phosphorus, and to prevent this oxidation in the finished pills the pharmacopœia directs that they be coated with balsam of Tolu.

Dose.—One pill.

PILULÆ RHEI COMPOSITÆ—Compound Pills of Rhubarb

(Pil. Rhei Co.)

Recipe.

Rhubarb, in No. 80 powder, *thirteen grammes*	13.0 Gm.
Purified Aloes, in fine powder, *ten grammes*	10.0 Gm.
Myrrh, in fine powder, *six grammes*	6.0 Gm.
Oil of Peppermint, *five-tenths of a milliliter*	0.5 mil
Water, *a sufficient quantity,*	
To make *one hundred pills*	100

Mix the oil of peppermint intimately with the powders, then incorporate sufficient water to form a mass; divide it into *one hundred pills.*

Dose.—Two pills.

PILLS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in each pill)	Excipient	Remarks
Pilulæ ad prandium (4 types).	Lady Webster's pill.	....	....	See below.
	Chapman's dinner pill.	Aloes 0.097 Gm.; mastic; ipecac, 0.065 Gm.; oil of fennel.	Diluted alcohol.	*Dose.*—1 pill.
	Cole's dinner pill.	Aloes, mass of mercury and jalap, of each 0.078 Gm.; antimony and potassium tartrate 0.0013 Gm	Syrup.	*Dose.*—1 pill.
	Hall's dinner pill.	Aloes 0.065 Gm.; extract of glycyrrhiza.	Soap and syrup.	*Dose.*—1 pill.
Pilulæ aloes et asafetidæ.	Pills of aloes and asafetida.	Aloes, and asafetida, of each 0.09 Gm.	Soap and water.	*Dose.*—1 pill.
Pilulæ aloes et ferri.	Pills of aloes and iron (U.S.P. VIII).	Aloes, and exsiccated ferrous sulphate of each 0.07 Gm.; aromatic powder.	Confection of rose.	*Dose.*—2 pills.
Pilulæ aloes et mastiches.	Pills of aloes and mastic (U.S.P. VIII).	Aloes, 0.13 Gm.; mastic 0.04 Gm.; red rose.	Diluted alcohol.	The well-known *Lady Webster's after dinner pill*. *Dose.*—2 pills.
Pilulæ aloes et myrrhæ.	Pills of aloes and myrrh (U.S.P. VIII).	Aloes, 0.13 Gm.; myrrh, 0.06 Gm.; aromatic powder.	Syrup.	*Dose.*—2 pills.
Pilulæ aloes et podophylli compositæ.	Janeway's pills.	Aloes, 0.065 Gm.; resin of podophyllum, 0.0325 Gm.; extracts of belladonna leaves, and nux vomica, of each 0.016 Gm.	The extracts mentioned.	*Dose.*—1 pill.
Pilulæ aloes hydrargyri et podophylli.	Triplex pills.	Aloes, 0.13 Gm.; mass of mercury 0.065 Gm.; resin of podophyllum, 0.016 Gm.	The mass of mercury mentioned.	*Dose.*—1 pill.
Pilulæ aloes, hydrargyri et scammonii compositæ.	Francis' triplex pills.	Aloes, resin of scammony, and mass of mercury, of each 0.055 Gm.; croton oil, 0.0032 mil; oil of caraway.	Tincture of aloes and myrrh.	*Dose.*—1 pill.
Pilulæ aloini compositæ.	Compound pills of aloin.	Aloin, 0.0325 Gm.; resin of podophyllum, 0.008 Gm.; extract of belladonna, 0.016 Gm.	The extract mentioned.	*Dose.*—1 pill.
Pilulæ aloini, strychninæ et belladonnæ.	Pills of aloin, strychnine and belladonna.	Aloin, 0.013 Gm.; strychnine, 0.0005 Gm.; extract of belladonna, 0.008 Gm.	The extract mentioned.	The well-known "*A.S.* and *B. pill*" *Dose.*—1 pill.
Pilulæ aloini, strychninæ et belladonnæ compositæ.	Compound A.S. and B. pills.	The above with extract of cascara sagrada (0.0325 Gm.) added.		*Dose.*—1 pill.
Pilulæ antidyspepticæ.	Antidyspeptic pills.	Strychnine 0.0016 Gm.; ipecac, 0.0065 Gm.; extract of belladonna leaves, 0.0065 Gm.; mass of mercury, 0.13 Gm.; compound extract of colocynth, 0.13 Gm.	The extracts mentioned.	*Dose.*—1 pill.
Pilulæ antimonii compositæ.	Plummer's pills.	Sulphurated antimony, and mild mercurous chloride, of each 0.04 Gm.; guaiac.	Castor oil.	*Dose.*—1 pill.
Pilulæ antiperiodicæ.	Warburg's pills.	Extract of aloes; rhubarb; angelica fruit; elecampane; saffron; fennel; zedoary; cubeb; myrrh; agaric; camphor; quinine sulphate, 0.09 Gm.	Extract of gentian.	*Dose.*—1 pill.
Pilulæ antiperiodicæ sine aloe.	Warburg's pills without aloes.	The above, with extract of aloes omitted.	....	*Dose.*—1 pill.

PILLS OF THE NATIONAL FORMULARY.—(*Continued.*)

Latin name	English name or synonym	Ingredients (figures show amount used in each pill)	Excipient	Remarks
Pilulæ catharticæ vegetabiles.	Vegetable cathartic pills, (U.S.P. VIII).	Compound extract of colocynth, 0.060 Gm.· extracts of hyoscyamus and leptandra; resins of jalap and podophyllum; oil of peppermint.	Diluted alcohol.	*Dose.*—2 pills.
Pilulæ colocynthidis compositæ.	Cochia pills.	Extract of colocynth, 0.011 Gm.; aloes, 0.13 Gm.; resin of scammony, 0.13 Gm.; oil of clove.	Diluted alcohol.	Used in England as *pilulæ cocciæ*. *Dose.*—1 pill.
Pilulæ colocynthidis et hyoscyami.	Pills of colocynth and hyoscyamus.	Extract of colocynth, 0.0065 Gm.; aloes, resin of scammony and extract of hyoscyamus, of each 0.097 Gm.; oil of clove.	The extracts mentioned.	*Dose.*—1 pill.
Pilulæ colocynthidis et podophylli.	Pills of colocynth and podophyllum.	Compound extract of colocynth, 0.162 Gm.; resin of podophyllum, 0.016 Gm.	Syrup.	*Dose.*—1 pill.
Pilulæ digitalis scillæ et hydrargyri.	Niemeyer pills for dropsy.	Digitalis, squill, and mass of mercury, of each, 0.065 Gm.	Clarified honey.	Also called *Guy's pills*. *Dose.*—1 pill.
Pilulæ ferri, quininæ, aloes et nucis vomicæ.	Quadruplex pills.	Exsiccated ferrous sulphate, quinine sulphate and aloes, of each, 0.065 Gm.; extract of nux vomica.	Extract of gentian.	*Pilulæ quadruplices*, N.F III. *Dose.*—1 pill.
Pilulæ ferri, quininæ, strychninæ et arseni fortiores.	Bitter metallic pills.	Reduced iron and quinine sulphate, of each 0.065 Gm.; strychnine and arsenic trioxide, of each, 0.0032 Gm.	Clarified honey.	*Pilulæ metallorum*, N.F. III. *Dose.*—1 pill.
Pilulæ ferri, quininæ, strychninæ et arseni mites.	Aitkin tonic pill.	Reduced iron; quinine sulphate; strychnine and arsenic trioxide, of each, 0.0013 Gm.	Clarified honey.	*Dose.*—1 pill.
Pilulæ glycerylis nitratis.	Pills of nitroglycerin.	Spirit of glyceryl trinitrate 0.065 Gm.; althæa.	Confection of rose.	Pilulæ glonoini N.F. III. *Dose.*—1 pill.
Pilulæ laxativæ compositus.	Compound laxative pills (U.S.P. VIII).	Aloin, 0.013 Gm.; strychnine, 0.0005 Gm.; extract of belladonna leaves: ipecac; glycyrrhiza.	Syrup.	*Dose.*—2 pills.
Pilulæ laxativæ postpartum.	Barker's postpartum pills.	Compound extract of colocynth, 0.11 Gm.; socotrine aloes, 0.055 Gm.; extracts of nux vomica and hyoscyamus; resin of podophyllum, 0.005 Gm.; ipecac.	Diluted alcohol.	*Dose.*—1 pill.
Pilulæ opii, digitalis et quininæ.	Niemeyer pills for phthisis.	Powdered opium, 0.01 Gm.; digitalis and quinine sulphate, of each 0.065 Gm.	Clarified honey.	*Dose.*—1 pill.
Pilulæ opii et camphoræ.	Pills of opium and camphor.	Powdered opium, 0.065 gm.; camphor, 0.13 Gm.	Clarified honey.	*Dose.*—1 pill.
Pilulæ opii et plumbi.	Pills of opium and lead.	Powdered opium and lead acetate, of each, 0.065 Gm.	Clarified honey.	*Dose.*—1 pill.
Pilulæ rhei.	Pills of rhubarb.	Rhubarb, 0.20 Gm. soap.	Water.	*Dose.*—1 pill.

DOSES OF OFFICIAL PILLS

As already mentioned, pills, troches, and suppositories differ from other classes of official pharmaceuticals taken internally in the fact that the finished products are subdivided into definite doses; hence while the dosage of other preparations are by weight or volume, we administer pills and troches by a certain number of subdivided particles. The pharmacopœial doses of all official pills are either one or two pills.

1 pill: Pills of phosphorus.
2 pills: Pills of aloes; asafetida; compound cathartic; ferrous carbonate; ferrous iodide; compound rhubarb.

COMPRESSED TABLETS

These are lenticular masses of medicinal substances forced into a solid mass by compression. Compressed tablets were introduced by Brockedon in 1843, and soon became popular by reason of their convenience and simplicity of manufacture. It must be said, however, that compressed tablets are open to the possible objection of insolubility. Many substances, when compressed sufficiently firmly to hold together, are very difficultly soluble. In the manufacture of compressed tablets this should be borne in mind, and care should be exercised in so blending the ingredients as to render them as soluble as possible under the circumstances.

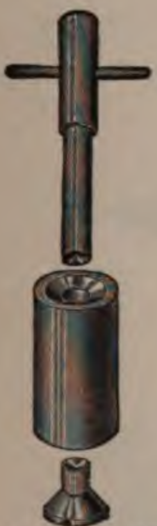

Fig. 207.—Compressed tablet mold.

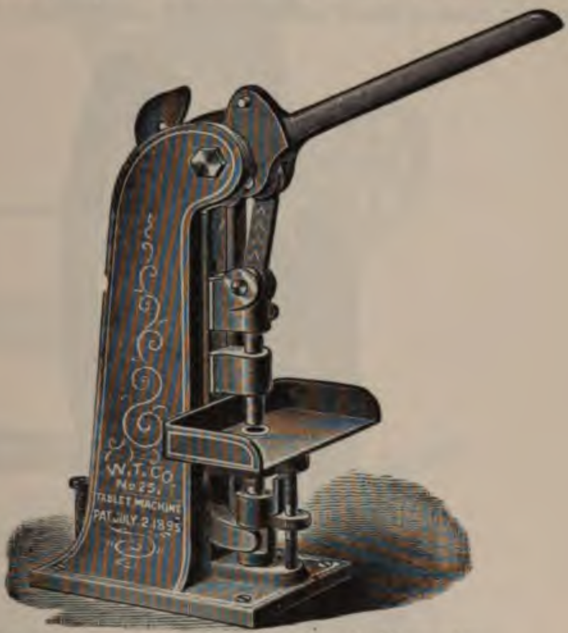

Fig. 208.—Compressed tablet machine.

The making of such compressed tablets depends chiefly on the proper blending of the ingredients, foreign substances being added either to secure solubility or to prevent sticking in the mold. These added inert constituents can be roughly grouped under the word excipient. For each combination of chemicals the excipient should be studied, even as we do in the case of pills, and the special directions are beyond the limits of this work. Suffice it here to cite a typical combination for a mass intended for compression. For this purpose a medicinal substance is combined with one-tenth its weight of sugar and one-twentieth its weight of gum arabic. The mass is then mixed with a little water, granulated by passing through a coarse sieve, and then carefully dried. The dried granular mass is then sprayed with liquid petrolatum, ten or twelve drops being enough for a pound of mass. Such mass, on compression, yields a tablet that is fairly soluble, while the lubricant (liquid petrolatum) is squeezed out upon the surface of the compressed tablet, thus preventing the mass from sticking to the mold.

For the purpose of preventing the mass from adhering to the dies of the machine, French chalk is sometimes used, although in general practice liquid petrolatum is more satisfactory.

In making compressed tablets of quinine it is essential that the quinine be in a satisfactory condition before attempting to compress it, as otherwise they are almost sure to adhere to the mold. The quinine should be at first sufficiently dried, and then should be granulated and sprayed with paraffin oil.

The apparatus used in compressing tablets consists, in its simplest form, of a steel cylinder pierced with a central bore, in which fits a plunger the end of which is convex, while at the other end of the cylinder fits the lower die, consisting of a cylindric piece of steel similar to the plunger, but shorter, terminating in a broad base. The cylinder is fitted to the lower die and the quantity of powder directed to be compressed is placed within the bore (Fig. 207). The plunger is then inserted, and the mass is then pressed against the lower die, forming a firm lenticular disk if the pressure be sufficient. The pressure is produced either by hitting the plunger with a hammer or mallet or by means of an iron lever. This lever is sometimes in the form of a long handle acting from a hinge. Of these machines, the one in which compression is performed with a hammer has fallen into disuse, on account of the noise accompanying the process and its general unsatisfactory character. The lever machine is simple and inexpensive, and should be found in every pharmacy for the

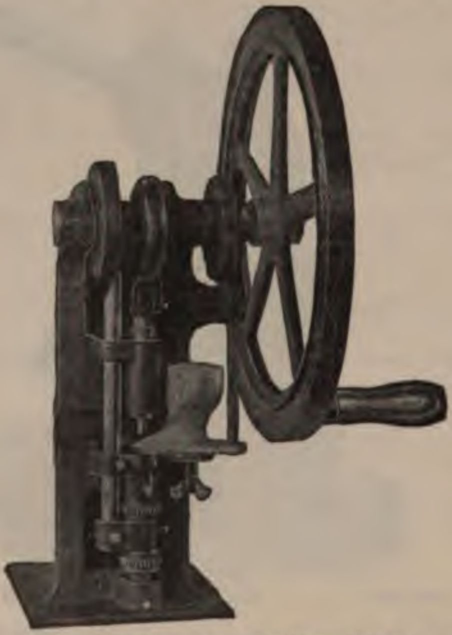

Fig. 209.—Stokes' "Eureka" tablet machine.

manufacture of extemporaneous tablets. An excellent modification of the lever compressor is shown in Fig. 208. A very good investment for the prescription department is the more expensive machine, as shown in Fig. 209. In these machines the tablet mass is blended, then placed in the appropriate funnel, and the mechanism is worked by a crank on the end of the circular wheel which transmits power not merely to cause the automatic rise and fall of the two dies, thus pressing the tablets, but the same movement also causes the throwing out of the funnel the quantity of the mass required for each tablet, and the flipping aside of the finished tablet. Such a tablet machine, known as the Stokes' "Eureka" machine, will readily make 100 tablets a minute. In large manufacturing concerns tablet machines having a higher efficiency are used, most notable of these being the Stokes'-Clark rotary tablet machine (Fig. 210). In this

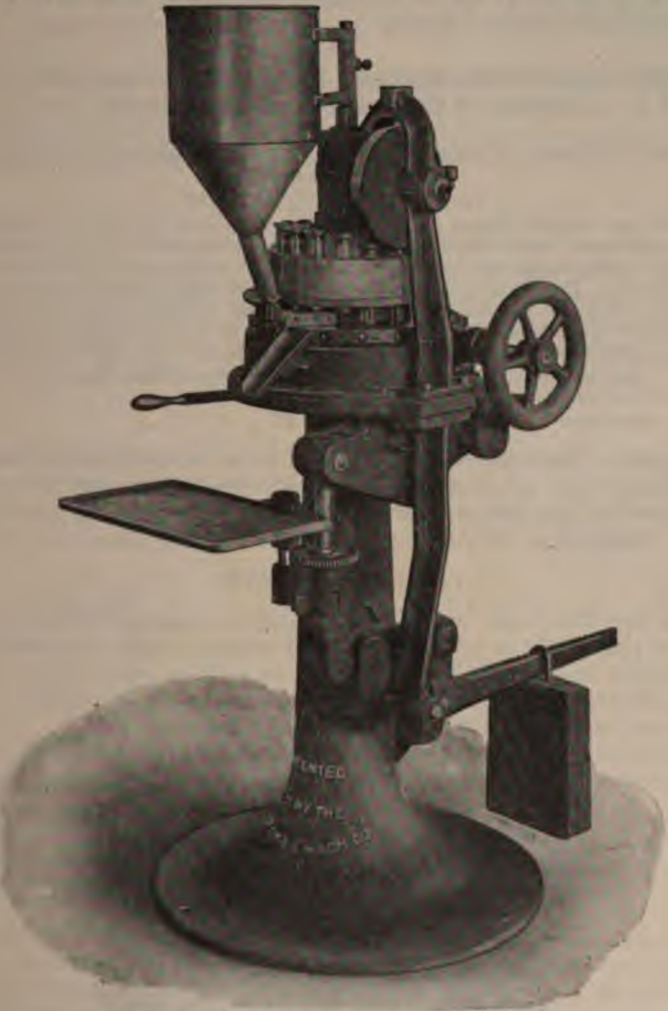

Fig. 210.—Stokes'-Clark rotary tablet machine.

machine there is a series of dies (12 to 25) operating on a circular plate, and being mechanically raised and lowered during the revolution of the plate by means of cams; each revolution of the plate, therefore, produces 12 to 25 tablets, and as the machine can be run very rapidly, it is capable of turning out from 30,000 to 50,000 tablets an hour.

For the first time, the present pharmacopœia recognizes a specific compressed tablet under the title

TOXITABELLÆ HYDRARGYRI CHLORIDI CORROSIVI—Poison Tablets of Corrosive Mercuric Chloride

(**Toxitabel. Hydrarg. Chlor. Corr.**—Corrosive Sublimate Tablets. Bichloride Tablets)

Tablets of an angular shape (not discoid), each having the word "POISON" and the skull and cross bones design distinctly stamped upon it. Each tablet weighs about 1 Gm. and contains not less than 0.45 Gm. nor more than 0.55 Gm. of corrosive mercuric chloride ($HgCl_2$); the remainder consisting chiefly of sodium chloride ($NaCl$). The tablets are to be colored blue, preferably with sodium indigotindisulphonate. Poison Tablets of Corrosive Mercuric Chloride are to be dispensed in securely stoppered glass containers on the exterior of which is placed a red label bearing the word "POISON" and a statement indicating that the Tablets contain the required amount of corrosive mercuric chloride.

Assay.—See Part V.

Remarks.—This "poison tablet" has been introduced in response to a demand that the use of antiseptic tablets containing mercuric chloride be safe-guarded by making them of distinctive shape and color. The official monograph given above is self-explanatory.

TABLET TRITURATES

These are flat disks containing medicinal substances, prepared by making a paste of the substance and forcing it into the orifices of a special tablet machine. This machine, as will be seen in Fig. 211, consists of a plate of steel or gutta-percha pierced with a number of accurately bored holes, all of which are of the same size.

The second part of the apparatus consists of a plate, which is studded with cylinders exactly fitting in the orifices of the perforated plate, and of sufficient length to project from 1/8 to 1/16 inch above the perforated plate when it is fitted on these cylinders.

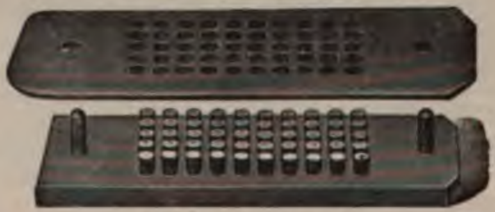

Fig. 211.—Tablet triturate mold.

In using such a tablet triturate machine, the mass, as above stated, is made into a thin paste by treatment with alcohol, and is forced into the orifices of the perforated plate (which rests on a pill tile or glass plate) by rubbing with a spatula, and the mass is left in holes until firm. The plate is then placed over the studded plate and gradually pressed down over the projecting posts. As these posts pass into the orifices of the perforated plate the dry disks of medicinal substances rise upon the posts and finally emerge from the plate in which they were formed, and they are allowed to remain on the top of the posts until perfectly dried, when a gentle tilting of the apparatus, or the tapping of it with a spatula, will cause them to fall off.

Tablet triturates were introduced in order to make preparations similar to compressed tablets, but more soluble by reason of their lesser compression.

The disadvantage of these tablet triturates lies in the fact that when they become dry they are liable to disintegrate, and care must be taken in dispensing such in a pill box to provide a sufficient amount of cotton to prevent their shaking to and fro.

HYPODERMIC TABLETS

These are frequently prepared by the same method of making tablet triturates. They consist of medicinal substances (intended to be administered subcutaneously) blended with a substance known to be completely soluble and inert. For this purpose sodium sulphate has been used, but now sugar of milk, especially that from goats' milk, is preferred. Most of the hypodermic tablets are now made by compression.

TROCHES

Troches or lozenges are disk-like masses of medicinal substances intended to be administered by slowly dissolving in the mouth. By reason of the method of administration the application of troches is limited to two classes of medicinal substances—first and usually, for the administration of medicines intended for application to the throat, and, secondly, in the administration of fairly mild and tasteless medicines in a palatable form. Since they are administered by slowly dissolving, no intensely bitter medicine should be used in the drug. Thus, to prepare troches of quinine sulphate would be scarcely short of senseless. A tasteless lozenge of quinine can, however, be made, and is described farther along.

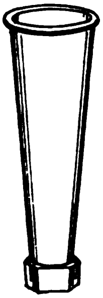

Fig. 212.—Lozenge cutter.

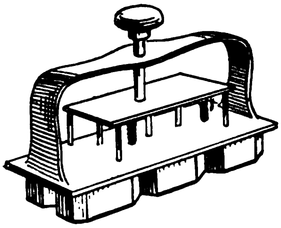

Fig. 213.—Sixfold lozenge cutter.

Troches are manufactured in two ways—by massing and by compression. In making a lozenge by massing, the medicinal substances are combined with some mucilaginous substance, usually gum tragacanth, and moistened with sufficient water to make a mass, and are then worked up in a mortar similar to making a pill mass. When the mass is formed, it is rolled out with an ordinary biscuit roller on the biscuit board or pill tile, and from this rolled-out mass the lozenges are cut with an appropriate cutter. The details of the manufacture of such a mass will be found in Part VII in the discussion of the manufacture of lozenges of potassium chlorate. The apparatus required, as mentioned above, is a biscuit board, which, however, in the writer's experience, is not as satisfactory (by reason of the warping of wood) as a glass plate, or, in making small quantities, a pill tile. For rolling out the mass any ordinary rolling-pin will answer, the size depending upon the number of troches intended to be made. As to the lozenge cutters, they are generally hollow cylinders of tin tipped with steel, as shown in Fig. 212. The shape of this can be either round or hexagonal. Special forms of lozenge cutters for cutting six at a time have been devised (see Fig. 213).

The making of lozenges by compression is similar to making compressed tablets, the only difference being in the size of the mold. In the case of compressed tablets, the die arranged for 1-grain masses has a diameter of ¼ inch; while the 5-grain die is ⅜ inch in diameter. The lozenge being usually larger, a special die is provided, with all compressed tablet machines, in which the diameter is ½ to ¾ inch. Such a die is attached to the tablet machine, the powdered constituents blended in the proper way, and compressed either by hand or by machine.

For throat troubles the compressed lozenges are as valuable as the massed lozenges, because in such cases the medicinal ingredients of these lozenges act best when they are slowly dissolved.

BACILLI

These are special forms of lozenges, consisting of cylinders about an inch in length and ⅛ to ¼ inch in diameter. The best illustration of bacilli are the black licorice lozenges so largely sold in America these days. Such bacilli are made by taking the mass and either rolling it into a cylinder by hand and dividing on a pill-cutting machine, or, better still, forcing it through a bougie machine (p. 326), from which it emerges as a narrow cylinder which is cut by a knife into short pieces.

TABLE OF OFFICIAL LOZENGES

(All Galenic)

Process	*Uses*	*Excipient*	*Preparations*
All by massing and cutting.	Throat lozenge.	Tragacanth and stronger orange flower water.	Troches of tannic acid.
		Tragacanth and syrup of tolu.	Troches of ammonium chloride.
		Tragacanth and water.	Troches of potassium chlorate.
		Acacia and syrup of tolu.	Troches of cubeb.
	Not for throat.	Mucilage of tragacanth.	Troches of sodium bicarbonate.

SPECIAL NOTES ON OFFICIAL LOZENGES

TROCHISCI ACIDI TANNICI—Troches of Tannic Acid

(Troch. Acid. Tann.)

Condensed Recipe.

Ingredients.—Tannic acid, 6 Gm.; powdered sugar, 65 Gm.; powdered tragacanth, 2 Gm.; stronger orange flower water, enough.

Manipulation.—Triturate the powders together, mass with the aromatic water and divide into 100 troches.

TROCHISCI AMMONII CHLORIDI—Troches of Ammonium Chloride

(Troch. Ammon. Chlor.)

Condensed Recipe.

Ingredients.—Ammonium chloride, 10 Gm.; powdered extract of glycyrrhiza, 20 Gm.; powdered tragacanth, 2 Gm.; powdered sugar, 40 Gm.; syrup of tolu, enough.

Manipulation.—Mix the powders by trituration, mass with the syrup and divide into 100 troches.

TROCHISCI CUBEBÆ—Troches of Cubeb

(Troch. Cubeb.)

Condensed Recipe.

Ingredients.—Oleoresin of cubeb, 2 Gm.; oil of sassafras, 1 mil; powdered extract of glycyrrhiza, 25 Gm.; acacia, 12 Gm.; syrup of tolu, enough.

Manipulation.—Triturate the powders, and mix them with the oleoresin and the oil, Mass with the syrup and divide into 100 troches.

TROCHISCI POTASSII CHLORATIS—Troches of Potassium Chlorate

Recipe and full details of manipulation will be found in Part VII.

Remarks.—These lozenges must not be confounded with the compressed *tablets of the potassium chlorate,* which usually consist of five grains of that chemical in compressed form.

In making the troches, great care should be taken in mixing the potassium chlorate with the sugar, that combination, as mentioned on p. 417, being apt to explode. Not only is caution required in the manufacture, but also it is well to warn the purchaser that these lozenges should not be subjected to any violent concussion, as such is apt to produce a dangerous explosion.

TROCHISCI SODII BICARBONATIS—Troches of Sodium Bicarbonate

(Troch. Sod. Bicarb.)

Condensed Recipe.

Ingredients.—Sodium bicarbonate, 18 Gm.; powdered sugar, 54 Gm.; freshly grated myristica, 1 Gm.; mucilage of tragacanth, enough.

Manipulation.—First triturate the nutmeg with the sugar; then with the sodium bicarbonate; mass with the mucilage and divide into 100 troches.

Remarks.—These lozenges are given as an antacid in cases of flatulence.

TROCHES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in each troche)	Excipient	Remarks
Trochisci carbonis ligni.	Troches of charcoal.	Charcoal, 0.30 Gm.; sugar; vanillin.	Tragacanth and water.	*Dose.*—1 troche
Trochisci gambir.	Troches of gambir(U.S.P, VIII)	Gambir, 0.06 Gm.; sugar; oil of cinnamon.	Tragacanth and water.	*Dose.*—1 troche.
Trochisci menthæ piperitæ.	Troches of peppermint.	Oil of peppermint, 0.01 mil; sugar.	Mucilage of tragacanth.	"*Peppermint drops.*" *Dose.*—1 troche.
Trochisci phenolphthaleini.	Troches of phenolphthalein.	Phenolphthalein, 0.06 Gm.; sugar; vanillin; carmine.	Acacia and water.	*Dose.*—1 troche.
Trochisci quininæ tannatis.	Lozenges of quinine tannate.	Quinine tannate, 0.06 Gm.; oil of theobroma; prepared cocoa; sugar; vanillin; sodium bensosulphinide. Chloroform to facilitate admixture.	Tragacanth and water.	Popular in the south under name of *quinine* lozenges. *Dose.*—1 troche.
Trochisci santonini.	Troches of santonin (U.S.P., VIII).	Santonin, 0.03 Gm.; sugar; prepared cocoa; vanillin.	Tragacanth and water.	*Worm lozenges.* *Dose.*—1 troche.
Trochisci santonini compositi.	Troches of santonin and calomel.	Santonin and mild mercurous chloride, of each, 0.03 Gm.; sugar; cocoa; vanillin.	Tragacanth and water.	*Dose.*—1 troche.
Trochisci sulphuris et potassii bitartratis.	Troches of sulphur and cream of tartar.	Washed sulphur, 0.30 Gm.; potassium bitartrate; sugar; oil of orange.	Tragacanth and water.	*Dose.*—1 troche.
Trochisci ulmi.	Troches of elm.	Elm, 0.20 Gm.; sugar; methyl salicylate.	Tragacanth and water.	*Dose.*—1 troche.

In England, lozenges enjoy far more popularity than they do in this country and there are several types not described in either the pharmacopœia or in the National Formulary.

Among these are *jujube paste lozenges*. The original jujube paste was the mucilaginous exudation from *Zizyphus sativa*, but it has long since been replaced by a base consisting of acacia, 18; sugar, 6; water, 80; evaporate in water-bath to 30 parts. With this base various medicines can be incorporated, and lozenges so prepared have been highly recommended by throat surgeons.

"*Glyco-gelatin*" *lozenges* are also very popular in England. These are made from a base which is prepared by soaking 1 ounce of gelatin in 2½ ounces of orange flower water until "jellified." To this is then added 2½ ounces of glycerin and enough carmine solution to color it. Gentle heat is then applied until the mass is fluid when it can be poured into molds. Of course, various medicines can be added to the base, while it is fluid.

Chloroform lozenges are now quite popular. These can be prepared by mixing together, 3.5 mils of chloroform, 0.5 mil of oleoresin of cubeb, 1 mil of tincture of capsicum, 0.3 mil of oil of anise, 5 Gm. of powdered extract of glycyrrhiza, 3 Gm. of powdered acacia, 5 Gm. of powdered elm and 82 Gm. of powdered sugar. The mixture is then beaten into a mass by addition of water and divided into 100 troches.

These lozenges lose their chloroform by evaporation in a comparatively short time, but when extract of licorice is used as a diluent, the chloroform remains for a longer time. The tincture of capsicum is added to bring out the cooling action of the chloroform.

DOSES OF OFFICIAL TROCHES

No doses are assigned troches by the pharmacopœia, it being assumed that they can be administered *ad libitum*. Warning must be given, however, that indiscriminate consumption of some medicinal lozenges may lead to grave results. This is especially true of troches of potassium chlorate (see p. 417) and troches of santonin N.F. (See p. 779.) The Formulary wisely directs a definite dose for each lozenge it describes.

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CHAPTER XX

SUPPOSITORIES

SUPPOSITORIES are solid bodies intended to introduce medicinal substances into the various orifices of the body. The medicament is incorporated in a base that melts at body temperature. The pharmacopœia gives a general formula for manufacture of suppositories and this should be carefully read by the student.

SUPPOSITORIA—Suppositories

Under this heading the present pharmacopœia prints a monograph discussing suppositories, their uses, their manufacture and their shape. The information given may be summarized as follows:

Suppositories are administered by inserting into rectum, vagina, or urethra, and according to place of insertion and material from which made, they are of different sizes and shapes, as tabulated below:

OFFICIAL SUPPOSITORIES

Application	*Composition*	*Shape*	*Weight*
Rectal.	Oli of theobroma.	Cone shaped.	2 grammes.
Urethral.	Glycerinated gelatin.	Pencil shaped.	2 to 4 grammes.
	Oil of theobroma.	Pencil shaped.	1 to 2 grammes.
Vaginal.	Glycerinated gelatin.	Globular or oviform.	10 grammes.
	Oil of theobroma.	Globular or oviform.	4 grammes.

Oil of theobroma suppositories can be made by fusion (p. 324) by massing (p. 324) or by cold compression (p. 325). In making suppositories containing phenol, hydrated chloral or other material which tend to soften the oil of theobroma, the addition of from 10 to 15 per cent. of spermacetti is permissible. The melting point of the finished suppository must not, however, be above 37°C.

Glycerinated gelatin suppositories are made by dissolving or mixing the medicine with glycerin, combining this with fused glycerinated gelatin and then pouring into greased molds. For details see U.S.P., p. 423.

The ideal suppository consists of medicine blended with some inert base which will not liquefy at ordinary temperatures, but will melt at the temperature of the human body. The best substance adapted for this purpose is oil of theobroma (butter of cacao); that is, the official solid fatty oil, which, as is explained on p. 659, is a hard, firm mass, which, however, melts to an oily liquid at 90° to 95°F. In America practically all suppositories are made from this substance, its use having been suggested by the American, A. B. Taylor, in 1852. In England glycerinated gelatin is popular as a suppository base, but this base possesses the decided disadvantage that the choice of medicinal ingredients to be blended with it is somewhat limited. Thus, under no circumstances should tannin or tannin-bearing drugs be combined with gelatin, for if this is done, an insoluble tannate of gelatin (leather) is formed.

A third suppository base, used only in one case, and that an official illustration, is the solidification of glycerin by means of stearic acid. This will be discussed in considering the official glycerin suppositories.

Manufacture of Suppositories.—There are three important ways of making suppositories—by *rolling*, by *molding*, and by *compressing*.

Of these processes, manufacture by rolling, that is, making into a mass, rolling out, cutting cylinder, and finally shaping by hand, and also by molding (or fusion), is outlined in above general directions, while minutiæ of each process, applied in special cases, is given in Part VII.

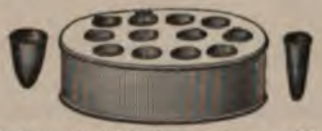

Fig. 214.—Individual suppository molds.

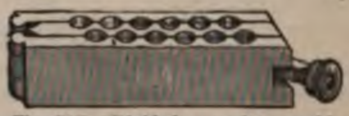

Fig. 215.—Divided suppository mold.

At this place it is, therefore, only necessary to say a few words concerning the apparatus (molds) used in preparing suppositories by fusion.

These molds are made of brass, usually nickel plated, and, before using are to be thoroughly chilled before the suppository mass is placed therein.

The first form of the suppository mold was the individual mold-consisting of a conic piece of steel hollowed out to the shape of a suppository, and a set of these molds is fitted into an appropriate holder which can then be immersed in ice-water, or a mixture of ice-water and salt, as shown in Fig. 214. These molds are absolutely useless in the modern pharmacy, there being no way of opening them to remove a possibly refractory suppository; and, moreover, the quantity of metal in the mold is not sufficient to insure a thoroughly uniform chilling. If such is used, the one way of removing the suppository is by tapping the mold, and if the mass sticks to the mold, nothing can be done except to dig it out by means of a wire or a file.

Divided molds consist of larger pieces of steel containing orifices for 6, 12, 24, or even a larger number of suppositories, so that they can be taken apart, thus dividing the mold in two pieces, as shown in Fig. 215. While being used, the two pieces are held together by means of clamps or pegs. Such molds are the most satisfactory that can be used, and if they have been left on the ice long enough to insure thorough chilling, the manufacture of suppositories with such molds yields most satisfactory results.

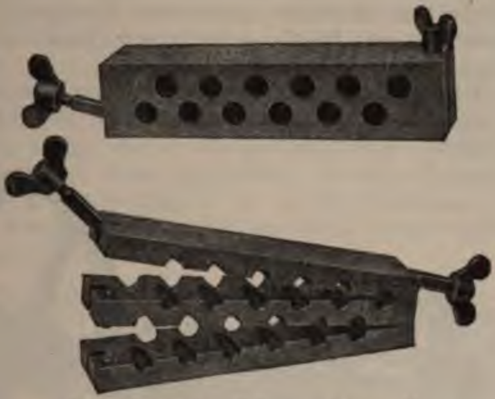

Fig. 216.—Benton-Hall suppository mold.

Quite a number of makes of divided suppository molds are on the market, and none of them is better than the hinged Benton-Hall mold, as shown in Fig. 216. It will be seen from the figure that this is on the same principle as the divided molds just described, but has the advantage of having a set of orifices at both top and bottom.

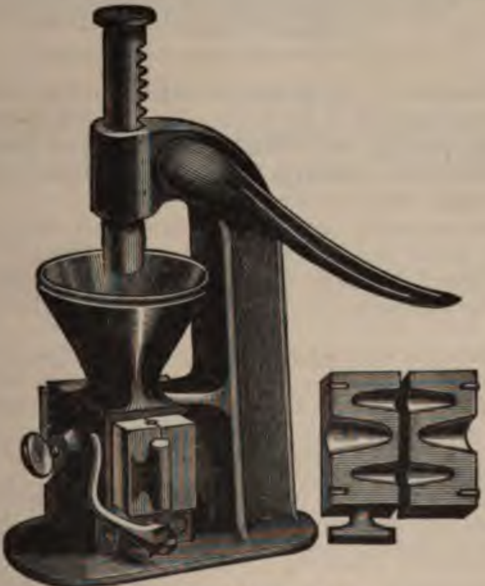

Fig. 217.—Suppository compresser.

Suppositories by compression are made by mixing the medicinal substance with finely grated oil of theobroma and compressing it into the mold by means of appropriate leverage. Several varieties of such compressing machines are on the market. Earliest of these was the Archibald suppository machine (shown in Fig. 217), in which the mixture was passed through a funnel in which works a steel plunger, which forces the mass into a mold placed underneath the funnel. This form of suppository machine is not highly satisfactory, however, and is rarely used in these days.

The Whitall-Tatum suppository machine works far more efficiently. The cylinder is smaller and rests horizontally on the table rather than vertically (Fig. 218).

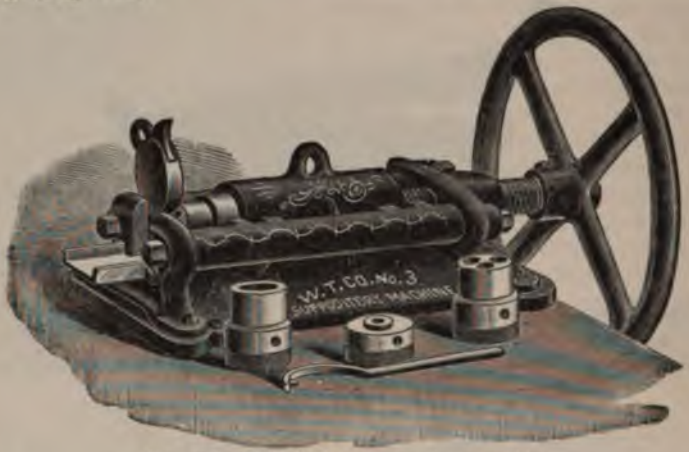

Fig. 218.—Whitall-Tatum suppository machine.

In making *bougies* by compression instead of the cone-shaped mold the mass is pressed through a die having a single but perfectly true cylindric orifice bored through it. The pressure of the plunger within the cylinder forces the mass through this narrow orifice, with the result of producing long, worm-like masses.

In lieu of compressing machines bougies can be made by working up the mass of hand and rolling it out as one would a pill cylinder. Or, if it is preferred to make the urethral suppository by fusion, the fused mass can be sucked up into a glass tube, which has been previously oiled.

The pharmacopœia recognizes but one suppository by name.

SUPPOSITORIA GLYCERINI—Suppositories of Glycerin

Recipe and details of manufacture of this important preparation are left for practice work in Part VII.

Remarks.—The mass from which the suppositories are made is prepared by treating glycerin with sodium carbonate and stearic acid, thus forming a glyceryl-sodio stearate, the chemistry of which will be discussed in Part VII.

It is here necessary merely to call attention to the fact that a very small quantity (less than 10 per cent.) of solids are able to solidify glycerin.

Suppositoria Boroglycerini (N.F.) or *suppositories of boroglycerin* are made by melting glycerinated gelatin and then adding to the fused mass glycerite of boroglycerin and glycerin. The mixture is then poured into molds. The suppositories contain 30 per cent. of glycerite of boroglycerin.

In place of ordinary suppositories there have been placed on the market the so-called *suppository capsules.* They consist either of a hollow mass of oil of theobroma, provided with a plug of the same material used to close the capsule; while others are made of gelatin, similar to gelatin capsules, only larger. In both cases the medicine intended to be administered as a suppository is supposed to be introduced into these capsules, which are then sealed and are then ready for insertion. It is hardly necessary to say that the careful pharmacist will avoid dispensing such suppositories. In the first place, one of the objects of using oil of theobroma mass is that the active medicinal ingredients shall be properly diluted, and to place these ingredients in such capsules, even though worked up with a small quantity of oil of theobroma, does not yield a suppository of a value equal to the one made by mixing the medicaments with the diluents.

Nasal coryza suppositories consisting of a base of oil of theobroma in which has been incorporated antiseptics such as oils of cassia, eucalyptus and thyme phenol, camphor and menthol have been suggested.

Politzer plugs are greased pellets of cotton about the size of a coriander seed with thread attached, for insertion in the ear as a protective.

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CHAPTER XXI

SOLID PREPARATIONS FOR EXTERNAL USE (CERATES, OINTMENTS, CATAPLASMS, PLASTERS, AND PAPERS)

CERATES

THESE are combinations of medicinal substances with fats and waxes intended to be used by spreading on cloth or paper, applying as one would a plaster. As the name suggests, cerates (from the Latin *cera*, wax) are supposed to contain wax, and a successful cerate should be soft enough to spread on cloth or paper, and yet thick enough not to become thin and oily in hot weather.

The statement as to the origin of the word cerate has lost some of its force since the last pharmacopœial revision, as one cerate now official (cerate of lead subacetate) contains no wax, paraffin being the hardening agent.

The fats used in the manufacture of cerates run the gamut of all available fatty substances. Lard is generally employed, but sometimes fatty oils are used; while in the present pharmacopœia petrolatum and lanolin are prescribed in several cases. According to the amount of semisolid fat, such as petrolatum or lard, or of oil employed, the amount of wax required must be varied; oils, of course, requiring a larger amount. Again, in several recipes for cerates and ointments in the present pharmacopœia directions are given to use more wax in hot weather than during the cold weather.

The official cerates are made either by *fusion* or by *incorporation*. In the manufacture by fusion the constituent having the highest fusing point—say the wax—is usually heated first and to this when melted is added the other constituents such as lard or petrolatum, when completely fluid, the melted mass strained through muslin into a mortar, and triturated until completely solidified. In incorporation the medicinal substance is placed on an ointment slab or in the mortar, and mixed with the fatty ingredients; in the first case, by rubbing with the spatula, and in the second, by trituration with the pestle.

In the present pharmacopœia all three official cerates are made by fusion.

TABLE OF OFFICIAL CERATES

(ALL GALENIC AND ALL MADE BY FUSION)

Base	*Preparations*
White wax, and benzoinated lard	Cerate.
Yellow wax and lard	Rosin cerate.
Yellow wax, benzoinated lard and rosin	Cantharides cerate.

SPECIAL NOTES ON OFFICIAL CERATES

CERATUM—Cerate

(Cerat.—Simple Cerate)

Condensed Recipe.

Melt 300 Gm. white wax on a water-bath, add 700 Gm. benzoinated lard; heat until all is liquefied, strain and then stir until solid.

Remarks.—This preparation, commonly called *simple cerate*, is made by the fusion of 30 per cent. white wax, and 70 per cent. benzoinated lard. Note the pharmacopœial proviso that the amount of wax may be varied to meet climatic conditions. In the last pharmacopœia, cerate was a mixture of white wax, white petrolatum and lard but at the recent revision it was decided to return to the old recipe of U.S.P. 1890.

Simple cerate is rarely used except in combination with medicinal substance.

CERATUM CANTHARIDIS—Cantharides Cerate

(Cerat. Canthar.—Blistering Cerate)

Condensed Recipe.

Ingredients.—Powdered cantharides, 350 Gm.; glacial acetic acid, 25 mils; oil of turpentine, 150 mils; yellow wax, 175 Gm.; rosin, 175 Gm.; benzoinated lard, 200 Gm.

Manipulation.—Macerate the cantharides with the oil of turpentine and the acetic acid in a warm place. Melt the rosin, wax and lard, add the cantharides mixture to the fused fat mixture and keep fused by heat of a water-bath until the ointment weighs 1000 Gm. For details see U.S.P., p. 105.

Remarks.—This is prepared by macerating powdered cantharides with liquid petrolatum and mixing the other fatty constituents previously brought to fusion, keeping the mixture in a liquid condition for an hour. After the heat is removed the mass is stirred until cooled. The cantharides cerate is used for spreading what is commonly known as *fly-blister*, this being the cerate spread on adhesive plaster in a layer about ¼ inch thick. This preparation is now given official recognition under the name, *cantharides plaster*. (See p. 341.)

CERATUM RESINÆ—Rosin Cerate

(Cerat. Res.—Basilicon Ointment)

Condensed Recipe.

Melt 350 Gm. rosin, add 150 Gm. yellow wax and 500 Gm. lard, heat until entirely fluid, strain and stir until solid.

Remarks.—This is best known by its synonym, *basilicon ointment.* It is made by the fusion of rosin, yellow wax, and lard, and it is worth noting that the pharmacopœia directs the changing of the proportion of the constituents according as the cerate is made in hot or cold weather.

The cerate has great popularity as a "drawing salve" for bringing boils "to a head."

CERATES OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 100 grammes)	Remarks
Ceratum camphoræ.	Camphor cerate (U.S.P. VIII).	Camphor liniment, 10 Gm.; white wax; white petrolatum; benzoinated lard.	This is *not* camphor pomade. See p. 337.
Ceratum plumbi subacetatis.	Goulard's cerate.	Solution of lead subacetate, 20 Gm.; wool fat; white wax; white petrolatum; camphor, 2 Gm.	Was official in U.S.P. VIII.
Ceratum resinæ compositum.	Deshler's salve.	Rosin; yellow wax; prepared suet; turpentine; linseed oil.	Was official in U.S.P. VIII.

OINTMENTS

Ointments are semisolid preparations containing medicinal substances blended with fatty matter of sufficient softness to permit their being applied to the skin by inunction. Ointments are always of softer consistence than are cerates, and have a lower melting-point, less wax being used. Thus while *cerate* of the present pharmacopœia contains 30 per cent. white wax, the official ointment contains but 20 per cent. of that hardening agent.

The choice of the *base* in making ointments is of much importance, since the medicaments contained in these preparations are supposed to be absorbed by the skin and if the base employed is not easily absorbed that result will not be obtained. Wool-fat is supposed to be the base most quickly absorbed, goose grease and lard come next, while petrolatum is considered to be very slowly absorbed.

Ointments are manufactured either by *fusion* or by *incorporation.* In fusion the fatty substances are liquefied by the aid of gentle heat, and the medicinal substances are incorporated either while the fats are liquefied or after solidification. In the case of the ointments made by incorporation the medicinal substances are rubbed up with solid fatty matter, either in a mortar or on an ointment slab. When pestle and mortar are used for the purpose of incorporation it is advisable to have the latter of a special flat shape, as shown in Fig. 219. An ointment prepared by fusion is usually finished by passing the fused mass through the strainer into a mortar, and triturating the mass until solidified. This has the effect of not only making the ointment smoother, but also lighter in color. In some of the ointments "whipping" is important in order to obtain a handsome product. Thus, in making cold-cream, the finished product is made light and fluffy by beating the mass with an egg-beater, and in making large quantities by working up in an emulsion machine (p. 261).

When an ointment is prepared by incorporation on a slab, the apparatus needed consists of an ointment slab and a spatula. For the slab the ordinary pill tile can be used, although more handsome forms of slabs, made of plate glass, are obtainable (Fig. 220). Some years since, the use of pads of parchment paper was suggested instead of the slab, the idea being that, after the finishing of each ointment, the sheet of paper on which the ointment was worked up would be torn off and thrown away. This scheme, however, is not very satisfactory, inasmuch as in many cases it is advisable to triturate the chemicals incorporated in the ointment with considerable pressure, and the excuse for the use of the paper pad—saving the trouble of cleaning the ointment slab—was scarcely worth notice.

The spatulas used in incorporating ointments should be long and pliable, those made of nickel-plated steel being preferable. The iron spatula, however, can be used in all cases with those chemicals which will not attack iron, but must not be used in making citrine ointment (containing nitric acid) nor iodine ointment. For the latter purpose the steel spatula, coated with gutta-percha or rubber, is very well adapted, although the objection to such gutta-percha spatulas is their tendency to peel. In preparing the ointment by incorporation on the slab the chemicals, which should be in a very fine divided form, are further subdivided by the process of levigation, using the end of the spatula blade in place of of the muller, and a portion of the ointment base as the lubricator. In the making of the ointment of the red mercuric oxide the chemical is to be levigated with water with the gutta-percha spatula—in this case it being essential that the chemical be reduced to the finest possible form of powder

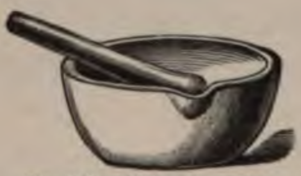
Fig. 219.—Ointment mortar.

Fig. 220.—Ointment slab.

TABLE OF OFFICIAL OINTMENTS

(All Galenic Except Ointment of Mercuric Nitrate)

Process	*Base*	*Preparations*
Fusion.	Lard.	Ointment of mercuric nitrate.
	Benzoinated lard.	Ointment of chrysarobin. Ointment of zinc oxide.
	Benzoinated lard and white wax.	Ointment.
	Lard and yellow wax.	Tar ointment.
	Ointment.	Ointment of phenol.
	White petrolatum and paraffin.	Ointment of boric acid.
	Expressed oil of almond, spermaceti, and white wax.	Ointment of rose water.
	White petrolatum.	Diachylon ointment.
Incorporation.	Benzoinated lard.	Iodoform ointment. Iodine ointment. Sulphur ointment.

Benzoinated lard and prepared suet.	Mercurial ointment.
Benzoinated lard and hydrous wool-fat.	Belladonna ointment. Stramonium ointment.
Ointment (U.S.P.).	Ointment of nutgall. Ointment of tannic acid.
Petrolatum.	Blue ointment.
Petrolatum and hydrous wool-fat.	Ointment of yellow mercuric oxide.
White petrolatum and hydrous wool-fat.	Ointment of ammoniated mercury.

SPECIAL NOTES ON OFFICIAL OINTMENTS

UNGUENTUM—Ointment

(**Ung.**—Simple Ointment)

Condensed Recipe.

Melt 200 Gm. white wax, add 800 Gm. benzoinated lard, heat until entirely fluid, then stir until solid.

Remarks.—This preparation, commonly called *simple ointment*, is used almost entirely as a base for medicated ointments. As seen from above table, it is so employed in three of the ointments of the present pharmacopœia. Note the pharmacopœial permission to increase the amount of wax employed, when climatic conditions render such a step advisable.

UNGUENTUM ACIDI BORICI—Ointment of Boric Acid

(Ung. Acid. Bor.)

Condensed Recipe.

Melt 50 Gm. paraffin, add 850 Gm. white petrolatum, heat until entirely fluid. Then pour little by little upon 100 Gm. powdered boric acid contained in a warm mortar, triturating until a smooth solid ointment results. For details see U.S.P., p. 476.

Remarks.—This official contains 10 per cent. of boric acid in an ointment base consisting of paraffin and white petrolatum.

UNGUENTUM ACIDI TANNICI—Ointment of Tannic Acid

(Ung. Acid. Tann.)

Condensed Recipe.

Dissolve 20 Gm. tannic acid in 20 Gm. glycerin by use of gentle heat and then mix with 60 Gm. ointment.

Remarks.—This ointment is made by combining a glycerinic solution of tannin with simple ointment. Iron vessels must be avoided in its manufacture, since tannate of iron would form and the product would blacken.

UNGUENTUM AQUÆ ROSÆ—Ointment of Rose Water

Recipe and details of manipulation will be found in Part VII.

Remarks.—This popular face salve, commonly called *cold-cream*, has the one drawback of rapidly turning rancid; hence the demand for a *theatrical cold-cream* for use by actors for cleansing the face from paints, and which will keep perfectly.

This is solved by the substitution of liquid petrolatum for the expressed oil of almond in the official recipe, though it is needless to say such a cold-cream should not be used in prescriptions.

UNGUENTUM BELLADONNÆ—Belladonna Ointment

(Ung. Bellad.)

Condensed Recipe.
Rub 10 Gm. pilular extract of belladonna leaves with 5 mils of diluted alcohol; then mix with 30 Gm. hydrous wool-fat and finally with 55 Gm. benzoinated lard.

Remarks.—In preparing this ointment the wool-fat is used to facilitate the absorption by the skin of the alkaloids of the extract.

UNGUENTUM CHRYSAROBINI—Chrysarobin Ointment

(Ung. Chrysarobin.)

Condensed Recipe.
Rub 6 Gm. chrysarobin with 94 Gm. melted benzoinated lard. Heat mixture on water-bath for twenty minutes, strain and stir until solid.

Remarks.—This is made by digesting chrysarobin in melted lard on a water-bath for twenty minutes and then stirring until congealed.

UNGUENTUM DIACHYLON—Diachylon Ointment

(Ung. Diachyl.)

Condensed Recipe.
Melt 50 Gm. lead plaster with 49 Gm. white petrolatum. Strain, add oil of lavender and stir until solid. For details see U.S.P., p. 478.

Remarks.—This is lead plaster softened with white petrolatum and flavored with oil of lavender.

UNGUENTUM GALLÆ—Nutgall Ointment

(Ung. Gall.)

Condensed Recipe.
Rub 20 Gm. powdered nutgall with 80 Gm. ointment.

Remarks.—Like ointment of tannic acid, and for the same reason, metallic utensils must not be used in making this ointment.

UNGUENTUM HYDRARGYRI—Mercurial Ointment

(Ung. Hydrarg.)

Condensed Recipe.
Triturate 500 Gm. mercury with 20 Gm. oleate of mercury. After standing fifteen minutes add about 25 Gm. of a melted mixture of benzoinated lard (250 Gm.) and prepared suet (230 Gm.) and triturate until the mercury is extinguished. Then add the rest of the melted fats and mix well. For details see U.S.P., p. 479.

Remarks.—Mercurial ointment is prepared on the same principle as blue mass, in that the mercury is finely divided and prevented from running together by coating each minute globule. In this ointment the mercury is extinguished with oleate of mercury and the globules are covered with lard and suet. Note that the globules must not be visible under a microscope magnifying ten diameters. Note that the present pharmacopœia provides an assay for the mercury that it contains. (See Part V.)

This 50 per cent. ointment is no longer called blue ointment, a diluted 33 per cent. form having been introduced at the eighth revision for dispensing under that synonym. (See below.)

UNGUENTUM HYDRARGYRI AMMONIATI—Ointment of Ammoniated Mercury

(**Ung. Hydrarg. Ammon.**— White Precipitate Ointment)

Condensed Recipe.

Ingredients.—Ammoniated mercury, 10 Gm.; white petrolatum, 50 Gm.; hydrous wool-fat, 40 Gm.

Manipulation.—Rub the ammoniated mercury with part of the melted white petrolatum, then with the rest and lastly with the wool-fat.

Remarks.—This preparation—called *white precipitate ointment*—is made partly by fusion and partly by incorporation; that is, the ammoniated mercury is rubbed with melted petrolatum and then with unmelted hydrous wool-fat. Petrolatum alone is but slightly absorbed by the skin. Combined with wool-fat it is fairly absorbable.

UNGUENTUM HYDRARGYRI DILUTUM—Diluted Mercurial Ointment

(**Ung. Hydrarg. Dil.**—Blue Ointment Hydrargyri unguentum P. I.)

Condensed Recipe.

Mix 600 Gm. mercurial ointment with 400 Gm. petrolatum. Yellow wax may be added to the petrolatum in warm climates. For details see U.S.P., p. 479.

Remarks.—This new official was introduced to give pharmacopœial sanction to the custom of dispensing a 33 per cent. mercurial ointment on calls for "blue ointment." It is commercially called "mercurial ointment ⅓." The use of petrolatum as a diluent is intentional, since the preparation is intended as an application for destroying body vermin and is not applied for the absorption of mercury through the skin.

UNGUENTUM HYDRARGYRI NITRATIS—Ointment of Mercuric Nitrate

Recipe and details of manipulation and full explanation of the chemistry of this important preparation will be found in Part VII.

UNGUENTUM HYDRARGYRI OXIDI FLAVI—Ointment of Yellow Mercuric Oxide

(**Ung. Hydrarg. Oxid. Flav.**)

Condensed Recipe.

Triturate 10 Gm. finely powdered yellow mercuric oxide with 10 Gm. water to a smooth paste. Then rub with 40 Gm. hydrous wool-fat and lastly with 40 Gm. petrolatum. For details see U.S.P., p. 480.

Remarks.—Made by levigating the oxide with water and then triturating with wool-fat and petrolatum. As to smoothness, see p. 330.

UNGUENTUM IODI—Iodine Ointment

(Ung. Iodi)

Condensed Recipe.
Dissolve 4 Gm. iodine and 4 Gm. potassium iodide in 12 Gm. glycerin and then incorporate with it, 80 Gm. benzoinated lard. For details see U.S.P., p. 481.

Remarks.—The iodine in this preparation, as in the compound solution of iodine, is made soluble by the use of potassium iodide. Note that the rubber-coated spatula should be used for mixing.

UNGUENTUM IODOFORMI—Iodoform Ointment

(Ung. Iodof.)

Condensed Recipe.
Triturate 10 Gm. iodoform with 90 Gm. benzoinated lard, added little by little. For details see U.S.P., p. 481.

Remarks.—The odor of the iodoform can be removed from the mortar by burning alcohol therein (p. 262). How the odor may be partially masked is suggested under Iodoform.

UNGUENTUM PHENOLIS—Ointment of Phenol

(Ung. Phenol.—Ointment of Carbolic Acid)

Condensed Recipe.
Melt 97.75 Gm. ointment and stir into it 2.25 Gm. phenol. For details see U.S.P., p. 481.

Remarks.—This preparation is a 2¼ per cent. mixture of phenol with white petrolatum and is known as *ointment of carbolic acid.*

Some pharmacists still dispense as *carbolic salve* ointment of carbolic acid (U.S.P. 1890), which contained 5 per cent. phenol with Ointment (U. S. P. 1890).

UNGUENTUM PICIS LIQUIDÆ—Tar Ointment

(Ung. Pic. Liq.)

Condensed Recipe.
Melt 150 Gm. yellow wax, then add 350 Gm. lard and warm until entirely fluid; add to 500 Gm. warmed tar, mix well, strain and stir until solid. For details see U.S.P., p. 482.

UNGUENTUM STRAMONII—Stramonium Ointment

(Ung. Stramon)

Condensed Recipe.
Identical with that for belladonna ointment except the use of pilular extract of stramonium and the proportion of hydrous wool-fat and of benzoinated lard (20:65).

Both ointments contain 10 per cent. of the characteristic extract.

Remarks.—This ointment is not the same as the ointment of stramonium of the pharmacopœia of 1890 which was made from extract of stramonium seed.

UNGUENTUM SULPHURIS—Sulphur Ointment

(Ung. Sulphur.)

Condensed Recipe.
Rub 150 Gm. sublimed sulphur, with 850 Gm. benzoinated lard. For details see U.S.P., p. 482.

Remarks.—The ointment of the present pharmacopœia contains just one-half as much sulphur (15 per cent.) as did the ointment of the pharmacopœia of 1890.

UNGUENTUM ZINCI OXIDI—Ointment of Zinc Oxide

(Ung. Zinc. Ox.—Zinc Ointment)

Condensed Recipe.
Melt 800 Gm. benzoinated lard and triturate about 200 Gm. of it with 200 Gm. finely powdered zinc oxide (free from grit). Then incorporate the rest of the lard. For details see U.S.P., p. 483.

Remarks.—In order to make this ointment (*zinc salve*) perfectly smooth and absolutely free from grit it is necessary, first of all, that the zinc oxide be the pure official product, and not the gritty white zinc oxide which sells at low prices as a pigment. (See p. 483.)

Dispensing Ointments.—The finishing and dispensing of ointments and cerates is a matter requiring attention. In the first place, it should be borne in mind that the ointments, especially those made of benzoinated lard, have a tendency to become rancid, and such rancid ointments should never be dispensed; hence incorporated ointments should be prepared freshly as required. Nor should an ointment be dispensed containing the slightest quantity of grittiness, and to prevent this it is necessary to rub the medicinal substance thoroughly with a small quantity of the fatty matter before incorporating the entire amount. This applies particularly to the ointments containing either of the two oxides of mercury, both of which are usually applied in cases of granulated eyelids. If any of the particles of mercuric oxide be still in the gritty form, it is sure to produce irritation. Hence the necessity of an absolutely smooth ointment.

Fig. 221.—Tin ointment box.

Fig. 222.—Ointment jar.

As to the dispensing of the ointment, it should never be sent out in a wooden box unless the wood of which it is made is prepared so as to be impervious to grease. Even in dispensing small quantities of ointment over the counter a wooden box should never be used, as grease soon penetrates the wood, and the purchaser has a greasy package, which is an abomination. For small retail sales the pressed tin box (Fig. 221) should be used exclusively.

In dispensing ointments on prescriptions one of the several varieties of ointment jars (Fig. 222) should be used. These usually consist of a glass jar with a metallic cover fastening to jar by a screw-joint. The cover is nickel plated, and the label should be pasted to the side of the glass jar. If it is desirable to use a rounded label on the cover, the form of ointment box shown in Fig. 223 should be used. When the label is placed on the side of the glass jar it invariably becomes greasy while in the cover just mentioned it is protected on top by a transparent sheet and underneath by card-board impervious to grease, and the label will, therefore, remain fresh for a long time. A recent and rather satisfactory way of dispensing ointments is in collapsible tubes (Fig. 224), being especially convenient for the person who expects to carry an ointment around with him. Filling such tubes is best done by rolling the ointment in waxed paper, slipping the roll into the tube and then, after pressing the paper firmly between thumb and forefinger of left hand slowly pulling the paper out with the right hand thus leaving the ointment in the tube. A special device called "Faltfona" is used in Germany for this purpose.

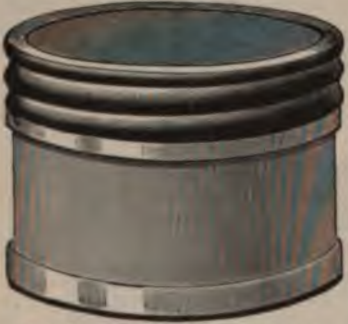
Fig. 223.—Ointment jar with mica top.

Fig. 224.—Collapsible tube.

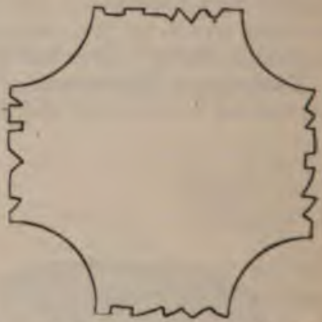
Fig. 225.—Tin ointment finisher.

In this connection it might be well to cite a novel method of dispensing a mercurial ointment now in vogue, which consists in placing in soft gelatin capsules sufficient of the ointment for one rubbing, the set of capsules being carried around in a pill box in the vest-pocket.

Old-time pharmacists, after placing the ointment in an ointment box, invariably "finished" them by ornamenting the surface exposed to the air with fanciful designs. These designs were made with specially cut pieces of tin (Fig. 225), which was held firm while the ointment in the jar was gradually rotating under it. This idea was admirable in showing the purchaser whether the ointment had been tampered with by the messenger, but is now rapidly becoming obsolete, the pharmacist and purchaser depending more on the external appearance of the package for signs of tampering.

Preservation of Ointments.—Ointments should be stored in a cool place, preferably in a refrigerator.

Unguentum solubile is an ointment base suggested by Stephan. This consists of a jelly made by triturating 3 Gm. of powdered tragacanth with 5 Gm. of alcohol, then adding 50 Gm. of glycerin and 42 Gm. of water.

OINTMENTS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Ingredients (figures show amount used in 100 Gm.)	Remarks
Unguentum calaminæ.	Turner's cerate.	Prepared calamine, 17 Gm.; ointment.	Also called *unguentum zinci carbonatis impuri.*
Unguentum camphoræ.	Camphor ointment.	Camphor 22 Gm.; white wax; lard.	Called *pomade camphree* in French speaking countries. Contains 11 times more camphor than does cerate of camphor, N.F.
Unguentum fuscum.	Mother's salve.	Camphorated brown plaster, 50 Gm.; olive oil; prepared suet.	Also called *unguentum matris.*
Unguentum hydrargyri oxidi rubri.	Ointment of red mercuric oxide (U.S.P. VIII).	Red mercuric oxide, 10 Gm.; water; hydrous wool-fat; petrolatum.	Also called *red precipitate ointment.*
Unguentum picis compositum.	Compound tar ointment.	Oil of tar, 4 Gm.; tincture of benzoin; zinc oxide; yellow wax; lard; cottonseed oil.	
Unguentum plumbi iodidi.	Ointment of lead iodide.	Lead iodide, 10 Gm.; benzoinated lard.	
Unguentum potassii iodidi.	Ointment of potassium iodide (U.S.P. VIII).	Potassium iodide, 10 Gm.; sodium thiosulphate; water; benzoinated lard.	Sodium thiosulphate used to decolorise iodine liberated from the iodide. Should be freshly prepared.
Unguentum resorcinolis compositum.	Compound resorcinol ointment.	Resorcinol, 6 Gm.; zinc oxide; bismuth subnitrate; rectified oil of birch tar; yellow wax; petrolatum; anhydrous wool-fat; glycerin.	Similar to the proprietary ointments containing resorcinol.
Unguentum sulphuris alkalinum.	Alkaline sulphur ointment.	Sublimed sulphur, 20 Gm.; potassium carbonate; water; benzoinated lard.	
Unguentum sulphuris compositum	Wilkinson's ointment.	Precipitated calcium carbonate; sublimed sulphur, 15 Gm.; oil of cade; soft soap; lard.	Also called *Hebra's itch ointment.*
Unguentum veratrinæ.	Veratrine ointment (U.S.P. VIII).	Veratrine, 4 Gm.; expressed oil of almond; benzoinated lard.	
Unguentum zinci stearatis.	Ointment of zinc stearate (U.S.P. VIII).	Zinc stearate, 50 Gm.; white petrolatum.	

SOLID PETROXOLINS

In addition to the liquid petroxolins, those liquid petrolatum preparations resembling liniments (see p. 267), the National Formulary provides recipes for two solid petroxolins, which are forms of petrolatum ointments containing ammonium oleate.

Petroxolinum Spissum (N.F.) is prepared melting together white wax and light liquid petrolatum, adding oleic acid to the mixture and triturating the fused fats in a warm mortar with a mixture of alcohol and stronger ammonia water. It is perfumed with oil of lavender.

Petroxolinum Hydrargyri (N.F.) or *mercury petrox,* is prepared by extinguishing mercury with hydrous wool-fat and oleic acid and then mixing with solid petroxolin. It contains 30 per cent. of mercury.

INUNCTIONS

Inuncta are ointments, in which hydrous wool-fat is the main fatty constituent. They contain medicaments intended to be quickly absorbed by the skin and in many cases are designed to produce local irritation. They resemble the "analgesic balsams" which are popular in Europe. The National Formulary recognizes the following:

Inunctum Mentholis (N.F.) is made by incorporating menthol (5 per cent.) in hydrous wool-fat.

Inunctum Mentholis Compositum (N.F.) contains menthol (5 per cent.), methyl salicylate (10 per cent.) and hydrous wool-fat. Inunctions are best dispensed in collapsible tubes.

DERMATOLOGIC PASTES

The National Formulary recognizes under the title *pastæ* dermatologicæ ointment-like mixtures of starch, dextrin, zinc oxide, sulphur, etc., made into a paste with glycerin, soft soap, petrolatum, lard or other fats. Recipes for the following are given:

Pasta Dextrinata (N.F.) a basic paste made from white dextrin, glycerin and water.

Pasta Betanaphtholis (N.F.) or *Lassar's naphthol paste*, made from beta-naphthol (10 per cent.), precipitated sulphur, petrolatum and soft soap.

Pasta Resorcinolis Fortis (N.F.) or *Lassar's stronger resorcinol paste*, made from resorcinol (20 per cent.), zinc oxide, starch and light liquid petrolatum.

Pasta Resorcinolis Mitis (N.F.) or *Lassar's mild resorcinol paste* made like the foregoing except that the resorcinol content is 10 per cent.

Pasta Zinci (N.F.) or *Lassar's zinc paste*, made of salicylic acid, zinc oxide (24 per cent.), starch and petrolatum.

Pasta Zinci Mollis (N.F.) or *Unna's soft zinc paste*, made from zinc oxide (25 per cent.), precipitated calcium carbonate, linseed oil and lime water.

Pasta Zinci Sulphurata (N.F.) or *Unna's sulphurated zinc paste*, made from zinc oxide (15 per cent.), precipitated sulphur, purified siliceous earth and benzoinated lard.

Unna recommends in certain cases where a protective coating containing medicinal substances is indicated. *Casein varnishes.* According to Hager such a varnish or paste can be made either by digesting 5 Gm. of casein with 0.6 Gm. of borax and 25 Gm. of water or else 1 part of casein is dissolved in 3 parts of 25 per cent. ammonia water, the solution mixed with 1 part of glycerin and heated on a water-bath until the excess of ammonia is driven off, after which 2 parts of boiling water are added to the residue and triturated until a smooth paste results.

MULLS OR STEATINS

These are ointments of high fusing points, containing the desired medicinal agents and spread on soft muslin or "mull." The National Formulary gives a general formula for mulls, under the title *Mullæ* in which the method of spreading is described at some detail. It also gives monographs on the following special mulls.

Mulla Acidi Salicylici (N.F.) made by mixing salicylic acid (10 per cent.) with benzoinated lard and benzoinated suet.

Mulla Creosoti Salicylata (N.F.) made from salicylic acid (10 per cent.), creosote (20 per cent.), yellow wax and benzoinated suet.

Mulla Hydrargyri Chloridi Corrosivi (N.F.) made by dissolving corrosive mercuric chloride ($\frac{2}{10}$ of 1 per cent.) in alcohol and mixing the solution with benzoinated lard and benzoinated suet.

Mulla Zinci (N.F.) made by mixing zinc oxide (10 per cent.) with the fats just mentioned.

GLYCEROGELATINS

These are soft masses containing medicinal substances used in dermatological practice made with glycerinated gelatin U.S.P. is a vehicle. They are firm enough to be molded and yet melt at the body temperature. The National Formulary recognizes the following:

Glycerogelatinum Acidi Salicylici (N.F.) is made by fusing glycerinated gelatin, glycerin, distilled water and salicylic acid (10 per cent.) and then pouring the homogeneous mixture into chilled molds.

Glycerogelatinum Iodoformi (N.F.) contains in molded form, glycerinated gelatin, glycerin, distilled water and iodoform (10 per cent.)

Glycerogelatinum Zinci Durum (N.F.) contains in molded form, glycerinated gelatin, glycerin, distilled water and zinc oxide (10 per cent.).

Glycerogelatinum Zinci Molle (N.F.) differs from the foregoing *firm zinc glycerogelatin*, only in the proportion of glycerinated gelatin and glycerin. In the firm glycerogelatin the proportion is 30 to 25; in the soft variety it is 20 to 35.

PASTE PENCILS

Stili Dilubiles or *Unna's pencils* are prepared by incorporating the medicinal agent (something used in dermatology) with a paste consisting of starch and other adhesive materials. The mass is rolled into thin cylinders (about ⅛ inch in diameter as in making pills and then cut into sections about 2 inches long and after drying, each pencil is wrapped in tin foil. The National Formulary recognizes:

Stili Acidi Salicylici Dilubiles (N.F.) or *salicylic acid pencil;* the mass of which contains salicylic acid (10 per cent.) tragacanth, starch, white dextrin, and sugar. Distilled water is used as the excipient. Each pencil will weigh slightly over 2 Gm.

CATAPLASMS

Cataplasms or *poultices* are wet masses of solid matter applied to the skin for the purpose of reducing inflammation, or in other cases to act as counter-irritants.

The solid matter used as the base is chosen with a view to its capacity to absorb water. Thus the base of the one official cataplasm is clay, while mucilaginous drugs, such as ground flaxseed, are valuable as poultice bases.

If the poultice is intended to reduce inflammation, the proper base is one devoid of medicinal action, and the poultice wet with cold liquid acts similarly to a cold compress (that is, a wad of cloth or cotton wet with water). If intended to act as a counter-irritant, the poultice is either applied hot or is made from some drug possessing rubefacient properties. An illustration of the latter case is formed in the poultice made of ground mustard, which is replaced in the pharmacopœia by the more elegant *mustard paper.*

The only cataplasm mentioned in either the pharmacopœia or the Formulary is:

Cataplasma Kaolini (U.S.P. VIII; N.F. IV) which consists of a mixture of kaolin, boric acid, and glycerin, flavored with thymol, methyl salicylate, and oil of peppermint, and which is similar to a widely popular proprietary preparation largely prescribed by physicians. It is indicated as a local application in a large number of inflammatory diseases, and is also of value as a mild antiseptic in minor wounds.

PLASTERS

Plasters are solid preparations containing medicinal substances intended to be applied to the skin, and of sufficient adhesiveness to adhere firmly. Plasters are different from cerates in being practically free from fats, and also in the fact that the cerates, when spread on cloth and applied, are not of sufficient adhesiveness to stick firmly to the skin, their removal being a very simple matter. Plasters, on the other hand, made of adhesive or resinous substances, stick very firmly to the skin; in fact, so firmly that it is sometimes a matter of difficulty to remove them.

As bases of plasters are used gum-resins, lead-plaster, resin plaster, Burgundy pitch, isinglass, and, latterly, India rubber. In former years the first-named plaster bases were used quite extensively, but during the last twenty years machine-made plasters with rubber base have practically driven the old-fashioned type of plasters out of the market, so that now the pharmacist is very rarely called upon to dispense a pharmacopœial plaster, and the art of spreading plasters is rapidly becoming a lost one.

Before discussing the official plaster masses a few words regarding the manufacture of rubber plasters may not come amiss.

The original and really satisfactory India-rubber plasters are made by kneading crude rubber with resinous substances, such as gum olibanum, until a plastic mass results. This kneading is accomplished by rolling the rubber between spiked hollow rollers heated by steam, the combination of the heat and the tearing effect of the spikes having the result of disintegrating the rubber into a thick, tenacious mass, with which the olibanum and other resinous mass combine admirably. The plaster mass is then spread on cloth by rolling between hot plates, both heat and pressure being required to spread it to the proper thickness. The making of such rubber plasters requires powerful and expensive machinery, and scarcely had the rubber plaster manufacture been placed on a paying basis, before other and inferior methods were substituted for the original process. In the cheaper methods the rubber is dissolved in the appropriate solvent, usually benzin, and the solution evaporated down to the consistence of a soft extract; and when it is spread on cloth, the surplus benzin is permitted to evaporate.

Such plasters are in every way inferior to the machine-kneaded plasters; the cohesive property of the mass is less, and such a plaster, on removal from the back to which it has been applied, very frequently tears off, leaving patches of the plaster sticking to the skin.

Of the pharmacopœial bases, a description had best be left for consideration under Special Notes.

The manufacture of pharmacopœial plasters may be divided into two parts: making the mass and spreading the same. The making of the official plaster mass is usually a matter of little difficulty, being generally prepared by fusing the various constituents or, in some cases, by softening them by gentle heat. The official plaster mass is then rolled into appropriate sticks, or left in the plaster dippers in which they have been fused, until a spreaded plaster is called for.

The spreading of a plaster is a matter calling for a high degree of skill and requiring much practice. Full details of the spreading of a plaster will be given in Part VII. So here suffice it to say that the molten plaster mass is spread on plaster skin or cloth, the area, including the dimensions directed by the physician, being inclosed in strips of paper, the entire paraphernalia—the cloth or skin base and the paper—being firmly fastened to a perfectly level table or to a smooth board resting on the counter by means of thumb tacks. So soon as the molten plaster mass is poured upon cloth or skin base, it is spread by the rapid movement of a hot, clean spatula. If, in spreading, the hand trembles or the plaster mass is not warm enough to follow the spatula, an unsuccessful plaster results.

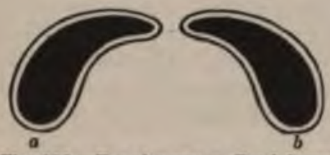

Fig. 226.—Ear plasters: a, For left ear; b, for right ear (Thornton).

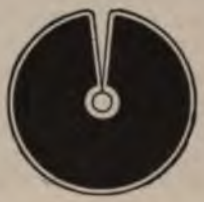

Fig. 227.—Breast plaster (Thornton).

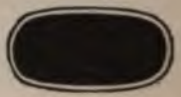

Fig. 228.—Kidney plaster (Thornton).

In former years there was considerable demand for specially shaped plasters, such as those to fit behind the ear, to cover the breast, or to place over the kidneys. These were spread on cloth by substituting for the plain paper strips above mentioned a pattern made of stiff paper, having cut out from its center the shape required for the plaster (Figs. 226, 227 and 228). The details of the spreading of the specially shaped plasters are exactly the same as for an oblong plaster.

In the old times, when plaster spreading flourished and numbers of plasters were called for in a day's prescription business, special apparatus was devised for spreading plasters by hand on a large scale. An example of these spreading machines is found in the plaster spreader, a picture of which is appended (Fig. 229).

At the present time there are few stores possessing such, the demand for hand-spread plasters being practically nil. Among the few survivors of hand-spread plasters are the so-called fly-blisters (see below).

The decline in the manufacture of plasters by the pharmacist is strikingly shown in the handling of the subject in the present pharmacopœia. In the pharmacopœia of 1890, thirteen plaster masses were official, while in the present pharmacopœia, although seven plasters are official, only four are supposed to be prepared by the druggist, the other three monographs describing the commercial finished plaster.

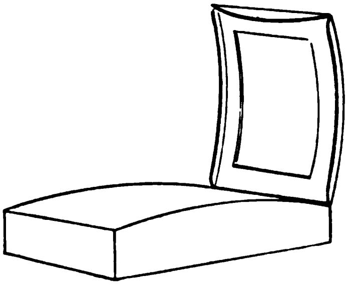

Fig. 229.—Plaster spreader.

TABLE OF OFFICIAL PLASTERS

(ALL GALENIC EXCEPT LEAD PLASTER)

Process	*Base*	*Preparations*
Commercial ready-made spread plaster.	Rubber plaster.	Belladonna plaster.
		Rubber plaster.
	Rubber on paper or cloth.	Mustard plaster.
Plaster masses made by fusion.	Lead oleopalmitate.	Lead plaster.
	Lead plaster.	Rosin plaster.
Spread plasters.	Rosin plaster.	Cantharides plaster.
	Rubber plaster.	Capsicum plaster.

SPECIAL NOTES ON OFFICIAL PLASTERS

EMPLASTRUM BELLADONNÆ—Belladonna Plaster

(Emp. Bellad.)

An adhesive plaster containing 30 per cent. of extract of belladonna leaves and yielding not less than 0.35 per cent. nor more than 0.40 per cent. of mydriatic alkaloids.
Assay.—See Part V.

Remarks.—This plaster, for the preparation of the mass of which former pharmacopœias gave minute directions, is now permitted to be the commercial machine-spread commercial product made with a rubber base. An elaborate assay is provided and the alkaloidal content must be from $^{35}/_{100}$ to $^{40}/_{100}$ of 1 per cent.

EMPLASTRUM CANTHARIDIS—Cantharides Plaster

(Emp. Canthar.)

Condensed Recipe.

Spread cantharides cerate on a piece of spread rosin plaster, leaving proper margin. Each square centimeter should contain 0.1 Gm. of the cerate. Permission is given to spread the cerate on muslin or on paper. For details see U.S.P., p. 134.

Remarks.—This new official plaster, the well-known *fly blister,* is cerate of cantharides spread on rosin plaster. In making it, a piece of the adhesive plaster of the appropriate size is cut off from the roll, the area to be covered inclosed by strips of stiff paper, and the cerate spread by means of a spatula over the exposed portion of the plaster. When spread, the plaster is sometimes finished by sprinkling with a small quantity of vinegar of cantharides or a minute trace of cantharides. Cantharides cerate is the most satisfactory method of producing a blister, and in inflammatory diseases the fly-blister is of the utmost value.

It will be noticed that the pharmacopœia directs that each square centimeter of plaster contains 0.1 Gm. cerate.

100 centimeters equal about 40 inches
1 centimeter equals about 0.4 inch
0.1 Gm. equals 1.5432 grains
1 square centimeter equals 0.4 × 0.4 or 1.6 square inches.

1.6 square inches of the plaster should contain about 1.6 grains of cerate. Hence 1 square inch contains about 1 grain of the cerate.

EMPLASTRUM CAPSICI—Capsicum Plaster

(Emp. Capsic.)

Condensed Recipe.

Oleoresin of capsicum is painted upon a piece of spread rubber plaster. Each 15 square centimeters of plaster should contain 0.25 Gm. of the oleoresin. For details see U.S.P., p. 135.

Remarks.—Explicit directions are given as to spreading this plaster the object being uniformly to distribute the oleoresin of capsicum as well as to limit the amount of this irritating substance employed. The oleoresin is chosen in preference to the drug because the latter, blended with the plaster base, would soon lose its activity. For this reason these plasters should be dispensed freshly prepared.

EMPLASTRUM ELASTICUM—Rubber Plaster

(Emp. Elast.—Rubber Adhesive Plaster)

A mixture of rubber, resins and waxes, with a filler of an absorbent powder, such as orris root or starch, mechanically mixed and spread upon cotton cloth or other fabric.

Remarks.—This new official represents the *rubber sticking plaster* of commerce. Ordinary sticking plaster is the official rosin plaster (see below).

EMPLASTRUM PLUMBI—Lead Plaster

Recipe and details of manufacture of this important plaster base, as well as full explanation of the chemistry of manufacture, will be given in Part VII.

EMPLASTRUM RESINÆ—Rosin Plaster

(Emp. Res.—Rosin Adhesive Plaster—Adhesive Plaster)

Condensed Recipe.

Melt 800 Gm. lead plaster with 60 Gm. yellow wax; then add the rosin and when liquefied, strain and stir until solid. For details see U.S.P., p. 135.

Remarks.—The above recipe marks a return to the adhesive plaster of the earlier pharmacopœias. The adhesive plaster of the last pharmacopœia containing only 2 per cent. of rubber proved unsatisfactory and therefore in the present revision, the old rosin plaster is provided for and an additional monograph is furnished for the rubber adhesive plaster of commerce. (See above.) Rosin plaster, when spread constitutes the old-fashioned *sticking plaster*. The spreading is done by means of a special apparatus consisting of reels on one of which the original bolt of cloth is placed; the unrolled cloth passing between the lower plate of stone or metal, and a receptacle containing the melted plaster mass; one side of the receptacle consists of a dull steel blade resting ⅛ or ¼ inch above the slightly stretched cloth. The melted mass trickles upon the cloth in a broad stream, covering the entire width of the cloth, save a small marginal edge. As the soft mass flows upon the cloth it is rapidly passed between the spreading apparatus described above, and emerges from the same with a thin and uniform coating of the plaster material.

EMPLASTRUM SINAPIS—Mustard Plaster

(**Emp. Sinap.**—Charta Sinapis, U.S.P. VIII—Mustard Paper)

A uniform mixture of black mustard, deprived of its fixed oil, and a solution of rubber, spread on paper, cotton cloth or other fabric. Preserve it in tightly closed containers. Each 100 square centimeters should contain 2.5 Gm. defatted black mustard.

Remarks.—In former editions of the pharmacopœia, this plaster was known as *mustard paper;* the only difference being that in the monograph just given permission is given to spread the material on cloth, as well as on paper. The plaster is prepared by mixing powdered black mustard (which has been freed from oil by percolation with benzin) with a solution of India rubber in benzin and carbon disulphide, and spreading the semiliquid magma on a piece of stiff well-sized paper (by means of a suitable brush), the pharmacopœia requiring that100 square centimeters of such paper should contain not less than 2.5 Gm. of black mustard deprived of oil. The object of first extracting the mustard with benzin is to free it from the fixed oil naturally existing in the seed, and which, if permitted to remain in the mustard paper, would rapidly cause it to become greasy and disagreeable to handle. Mustard paper (*mustard leaves*, as they are called) affords an elegant and convenient method of applying the mustard plaster. When such a mustard leaf is dipped into warm water, a chemical action sets up between the ferment myrosin and the glucoside potassium myronate, naturally existing in the mixture, with the formation of the volatile oil of mustard. (See p. 675.) The pharmacopœia directs that the leaf be dipped in warm water, since dipping it in cold water retards the chemical action to a certain extent. On the other hand, it is far preferable to dip into cold water than into hot water, and under no circumstances should the mustard paper be moistened with boiling water, as the heat is sufficient to destroy the delicate ferment, myrosin, and thus prevent the formation of the volatile oil.

Mustard leaves are applied externally as a rubefacient and local irritant, being particularly adapted for cases of acute indigestion.

Emplastrum Ichthyocollæ (U.S.P., 1890) is made by spreading aqueous solution of isinglass by means of a brush upon taffeta, successive layers of isinglass being applied to this fabric (a variety of silk) until the coating is sufficiently thick. The last portion of isinglass solution is mixed with alcohol and glycerin and applied in the same manner. The back of the taffeta is then spread with tincture of benzoin, and the official plaster allowed to become perfectly dried. Isinglass plaster is the well-known *court-plaster*, and is intended for adhesive purposes in simple operations, such as bringing the two edges of open cuts together. It has no medical action.

Emplastrum Picis Burgundicæ.—This is made by softening Burgundy pitch with yellow wax and olive oil, the Burgundy pitch being so brittle that, if melted and spread on cloth by itself and allowed to become quite cold, the finished plaster will break very quickly. Burgundy pitch plasters formerly enjoyed a large sale under the name of "*poor man's plaster.*

PLASTERS OF THE NATIONAL FORMULARY

Latin name	English name or synonym	Preparation	Remarks
Emplastrum fuscum camphoratum.	Camphorated brown plaster.	Red oxide of lead is boiled with olive oil and then mixed with yellow wax and camphor (1 per cent.).	Also called *camphorated mother plaster*.
Emplastrum saponis.	Soap plaster (U.S.P. VIII).	Soap is made into a paste with water and incorporated into melted lead plaster.	

PAPERS

These represent a class of pharmaceuticals in which the medicine is either spread upon paper or absorbed by it.

Charta Sinapis (U.S.P. VIII) is now included among the plasters (p. 343).

Charta Potassii Nitratis (U.S.P. 1890; N.F. IV) is made by dipping white, unsized paper (either filter-paper or blotting-paper) into a 20 per cent. aqueous solution of potassium nitrate, and drying the pieces so dipped. It is intended to be burnt and the vapor inhaled in cases of asthma.

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PART III

CHAPTER XXII

INTRODUCTION

A THOROUGH explanation of the sciences of physics and chemistry is beyond the scope of this work, and for complete information on these two sciences the reader is referred to the several works on these subjects noted in the Preface to this work.

There are, however, some facts connected with these two sciences the knowledge of which is essential to a student of the succeeding chapters of this work, and these essential facts are here given.

Matter is anything that has extension (possesses length, breadth, and thickness) or is appreciable to our senses (can be seen, felt, tasted, or smelled). Thus, water is matter, and likewise anything else on this earth or in the air around us, which we can touch, which our senses tell us exist is matter. All matter is divided into solids, liquids, and gases.

A *solid* is that form of matter which holds a definite shape—whose molecules do not move among themselves.

A *liquid* is that form which is mobile—which assumes the shape of the vessel in which it is placed; whose molecules move freely among themselves.

A *gas* is that form of matter whose molecules tend to separate from one another.

When we call any portion of matter a solid a liquid, or a gas, we mean that it usually assumes the form which we call it. We know that water, usually a liquid, can be frozen into a solid—ice—or converted by heat into gas—steam. Such is the case with all other matter. Each kind of matter can be changed from the form it usually assumes—be it solid, liquid, or gas—into the other two forms, although sometimes the conversion is very difficult.

Thus, we formerly talked of "permanent gases," by which was meant such gases—air, for instance—that could not be converted into the forms of liquid or solid; but lately not only have the so-called "permanent gases" been turned into liquids, but into solids as well.

The word "*molecule*," used above, is one of the classes into which we group matter, according as we can divide it or break it up. A piece of coal can be taken and broken up into small pieces. These small pieces can be finely powdered, and by certain means we can divide it still more minutely. According to how far this division is carried on we group matter into masses, molecules, and atoms.

A *mass* is any particle of matter appreciable to our senses. Thus, a big lump of coal or the finest particle of its powder are alike masses.

A *molecule* is the smallest particle of matter than can exist in a free state.

Thus, if we take a dye, dissolve it in water, and keep on diluting the solution, the color grows fainter and fainter until finally we reach a point where the tint almost disappears. It is at a dilution beyond this point where we get the dye divided into its molecules. The eye can observe some very high dilutions; thus, Hoffmann found that one-seven-millionth of a gramme of dye in 1 mil of solution still had a pink tint. Molecules, however, are much smaller than the above illustration would indicate. Van der Waals has calculated that 1 gramme of hydrogen contains 35×10^{22} molecules, that is, in 1 gramme there are 350,000,000,000,000,000,000,000 or 350 sextillion molecules, a figure almost beyond the grasp of the intellect.

Finally, we can imagine a subdivision so minute that the dye is separated into the carbon, hydrogen, oxygen, and nitrogen of which it is composed. Then we have reached the atom.

An *atom* is the smallest particle which enters into a chemical combination. *An atom cannot exist in a free state.*

According to Thomson's theory, atoms consist of hollow spheres ("shells") of positive electricity containing *electrons* or *corpuscles* of each having about 1/1700th of the mass of a hydrogen atom. These electrons seem to be nothing less than what we have hitherto called negative electricity.

Physics treats of the *molecular* changes of bodies, while *chemistry* studies the *atomic* changes.

Thus, we heat an iron rod. It turns red and finally softens and glows with white light. But when we allow it to cool, we find it unchanged. In other words, the molecules were temporarily changed. The iron had undergone a *physical change.*

We take powdered iron and powdered sulphur and rub them together, when we get a grayish-yellow powder from which we can separate the iron with magnet or can see its minute particles through a microscope. Intimate though the incorporation may seem, we have merely a mechanical mixture, the molecules of the iron and of the sulphur being absolutely unchanged. We heat this mixture; not merely do the sulphur and the iron molecules undergo the physical change called heating, but the molecules are broken up, the atoms of which they are composed enter into the play, and, through the breaking of the old association and the formation of the new, we get a steel-gray solid, totally different from the iron and the sulphur of which it is composed, from which the iron can no longer be obtained by the magnet; in which we can no longer see the particles of iron by means of the microscope. We have a new compound —iron sulphide; for the molecules of iron and sulphur have broken up, their constituent atoms uniting in another combination. Such is a *chemical change.*

Many phenomena which we study in pharmacy are due to attractions exerted between atoms or molecules. Such attractions were formerly called forces, and we still speak of the "force of gravity," the "force of chemism," etc. The word "force" being now, however, used in a more restricted sense in physics, its application in the above cases is no longer usual.

Important among these attractions are cohesion, adhesion, and chemism.

Cohesion is that attraction exerted between *like* molecules. Thus, when we take two pieces of freshly cut lead and press them together they stick. Likewise a huge mass of lead holds together and does not fall to powder because its molecules cohere.

Adhesion is the attraction exerted between *unlike* molecules. Thus, in sticking a label on a bottle the molecules of the mucilage adhere to the molecules of the paper on one side and of the glass on the other.

Chemism is the attraction exerted between atoms. It acts only *within* the molecule, and is exerted only between definite weights of matter.

We have spoken of carbon, hydrogen, oxygen, nitrogen, sulphur, and iron. What are such kinds of matter? You will notice that we have spoken of *atoms* of these kinds of matter; so you can see that they are capable of very fine division.

Let us think of a mass of sea-water. If we attempt to separate it into its constituents, we will find water, salt, magnesium chloride, and many other bodies. Suppose we analyze the salt it contains. This we can divide into sodium and chlorine. Turning our attention to the separated sodium and chlorine: can we break them up as we have the salt or the sea-water? We cannot, and such matter that cannot be broken into anything simpler we call *elements.*

An element is matter that cannot be broken into anything simpler. Over eighty elements have been isolated, and of these, less than half are of interest in pharmacy.

A table of those of pharmaceutic importance will be found on p. 352, each accompanied by its symbol, atomic weight, and valence, and grouped in one of the two columns according as it is electropositive or electronegative.

By *symbol* we mean an abbreviation representing the element.

The abbreviation is usually the first letter of the Latin name of the element, but when that letter is already the symbol of an element, then a second letter is added to make the symbol distinctive.

Thus:

	LATIN	SYMBOL
Carbon.	Carbo.	C.
Calcium.	Calcium.	Ca.
Cerium.	Cerium.	Ce.
Cobalt.	Cobaltum.	Co.
Copper.	Cuprum.	Cu.
Columbium	Columbium.	Cb.
Cadmium.	Cadmium.	Cd.
Chlorine.	Chlorum.	Cl.
Chromium.	Chromium.	Cr.
Cæsium.	Cæsium.	Cs.

This symbol does not merely mean the element in question in a general way, but when written, indicates the quantity of the element. Thus Ca means one atom of calcium. If we desire to express any other number of atoms, we do so by placing below and to the right of the symbol a small Arabic number representing that quantity.

Thus, while Ca means one atom of calcium
Ca_2 means two atoms of calcium
Ca_3 means three atoms of calcium, etc.

By *symbolic formula* we mean a combination of symbols expressing the composition of a compound molecule. Thus, NaCl means one atom of sodium and one atom of chlorine, making together one molecule of sodium chloride.

H_2SO_4 means two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen, making together one molecule of sulphuric acid.

KNO_3 means one atom of potassium, one atom of nitrogen, and three atoms of oxygen, making together one molecule of potassium nitrate.

ATOMIC WEIGHT

The atomic weight of an element is *the relative combining weight of that element* when compared to hydrogen—the lightest of all substances—as a unit.

Elements combine with each other only in definite proportions. Thus, it has been proved, time and again, that if 63 Gm. of pure copper be heated in a stream of oxygen, 79 Gm. of copper oxide invariably result. This shows that the relative weights when copper and oxygen combine are respectively 63 and 16 $(63 + 16 = 79)$.

But how do the combining weights of these elements compare with hydrogen? Copper and hydrogen scarcely unite. Oxygen and hydrogen do; although the estimation of the combining proportions of the two is more complicated than that between copper and oxygen, and an explanation is needed.

It is found that *two* volumes of hydrogen gas (let us say, for example, two pints) unite with *one* volume of oxygen gas (say, one pint) to form water, and this is still better proved by the fact that water, decomposed by electricity, gives always *two* volumes of hydrogen to *one* of oxygen.

An Italian named Avogadro framed a law that equal volumes of different gases contained the same number of molecules. Then, if water is composed of two volumes of hydrogen and one volume of oxygen, and if, further, both hydrogen and oxygen contain two atoms in each molecule, as will be shown later, then the formula of water is H_2O and not HO.

Now, water is composed of two *volumes* of hydrogen and one *volume* of oxygen. By weight, however, it is made from the proportion of *one* gramme of hydrogen and *eight* grammes of oxygen. By uniting the two statements just made, it will be seen, while there is in water only *half* as many volumes of oxygen as of hydrogen, the weight of that quantity of oxygen is eight times greater than the double volume of hydrogen employed. If half weighs eight times as much, then a whole (equal volume) would weigh sixteen, and we, therefore, see that were hydrogen and oxygen to unite volume for volume the relative combining weights would be 1 to 16. Since hydrogen is the lightest of all known matter, it is given the atomic weight, 1; therefore, we say that the atomic weight of oxygen is 16, and, by the same reasoning, that of copper is 63. By similar experimentation, some of which was exceedingly ingenious, the atomic weights of all the elements have been established.

Atomic weight is sometimes supposed to represent relative weight of an atom of the element under consideration, but, as we have never obtained a free atom of any element, that definition of atomic weight had better be dropped.

It will be noticed, in the table of elements given on p. 352, that the atomic weights are expressed in round numbers, while the atomic weights given in the pharmacopœia and other standard works are figures with decimal fractions attached.

Thus, while the table on p. 352 gives the atomic weight of sulphur as 32, the pharmacopœia gives it as 32.07; while the table gives the atomic weight of potassium as, 39 the pharmacopœia gives it as 39.10; and so in many other cases. Space forbids a discussion of the controversy as to whether the "exact" atomic weights (the figures showing fractions or the weights expressed in round numbers) are the true atomic weights. Suffice it to say that in the table in this book the round numbers are given, first, because the memorization of the fractional numbers is a matter of difficulty—and the table under consideration should be memorized—and, second, the so-called "exact" atomic weights change year by year with the publication of new researches with the combining weights of the elements; moreover, for all the practical purposes of pharmacy, the round number atomic weighs are sufficiently exact.

We have explained atomic weight, and it remains to define molecular weight.

The molecular weight of a substance is the sum of the atomic weights of its constituent atoms. Thus, the molecular weight of sodium chloride (NaCl) is:

Na, atomic weight........	23.0
Cl, " "	35.5
NaCl, molecular weight....	58.5

Of Ca Cl_2:

Ca, atomic weight....40	Ca	$= 1 \times 40 = 40$
Cl, " " 35.5	Cl_2	$= 2 \times 35.5 = 71$

Ca Cl_2, molecular weight, 111

We have means of estimating molecular weight that are quite different from the process of finding the atomic weight of elements, and, as the molecular weight of elements found by such processes are almost always twice the atomic weight, we are led to believe that most elemental molecules contain two atoms.

Thus, the molecular weight of oxygen is 32; the atomic weight is 16; therefore a molecule of oxygen must be O_2. On the other hand, while the atomic weight of mercury is 200, its molecular weight estimation gives the same figure, and we are, therefore, forced to the conclusion that a molecule of mercury consists of one atom.

Again, atomic weight estimation of phosphorus shows 31 as its relative combining weight, while its molecular weight has been experimentally proved to be 124; hence one molecule of phosphorus must contain four atoms.

VALENCE

Valence is *the relative power which an element* exerts in uniting with or replacing other elements. Thus, analysis of the four typical compounds cited below gives the formula there stated:

Hydrochloric acid........	HCl.
Water..................	H_2O.
Ammonia gas...........	H_3N (or NH_3).
Methane (marsh-gas)....	H_4C (or CH_4).

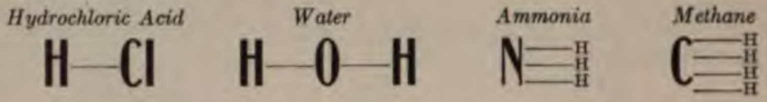
Why is it that while chlorine unites with one atom of hydrogen, oxygen can take up two, nitrogen (N) three, and carbon (C) four atoms of hydrogen? Simply because carbon has four times the combining *power* of hydrogen or chlorine, and twice the combining *power* of oxygen. Valence has nothing to do with atomic weight. While the latter concerns itself over combining *weight,* valence refers only to combining *power.* That carbon has the valence four—has four times the combining power of hydrogen—is analogous to the fact that a four-dollar check would have four times the purchasing power of a one-dollar check. Akin to this is the illustration that a man with four hands could do four times as much grasping as a man with one hand. This brings up the graphic way of illustrating valence called after its originator, "Frankland's bonds."

Frankland represented valence after this idea of hands, sketching the symbol of the element with as many lines as its valency.

Thus:

Hydrogen	with valence	one	is sketched as	H—
Chlorine	"	one	"	Cl—
Oxygen	"	two	"	O=
Nitrogen	"	three	"	N≡
Carbon	"	four	"	C≣

while the compounds cited above are given the following graphic formula:



To get the idea of valence imagine hydrogen and chlorine as one-armed men clasping hands; oxygen, with two hands going down the street with two single-handed hydrogen atoms; nitrogen as a three-handed being, and carbon as possessing four hands.

It is hardly necessary to state that this picture is purely fanciful; that this combining power must, in truth, consist of an atomic attraction somewhat similar to the attraction of gravitation as exerted between masses. Or perhaps that variation of combining power may be the proportional variation of electric manifestation.

In fact, there is some question among chemists in these days as to the entire theory of valence, and especially as to the varying valences exhibited by the same element, noted in the following pages.

But be this as it may, the fact still remains that the theory of valence affords the only rational and practical way of learning to write the symbolic formulæ of chemicals, and in this spirit the subject is discussed in these pages.

In the four compounds given as examples of valence, hydrogen plays a leading part, but when we consider the entire vast mass of chemical compounds we find that the hydrogen compounds are few, and that oxygen is the element preëminent for combinations. This is well shown in the combinations of chlorine. Hydrogen and chlorine unite to only one compound, the hydrochloric acid (HCl) given above. But when we look up the combinations of chlorine and oxygen, either free or in combination, we find four different bodies having the following formulas:

$$Cl_2O, \quad Cl_2O_3, \quad Cl_2O_5, \quad \text{and } Cl_2O_7.$$

We know that the valence of oxygen is two, that each atom has two bonds: then let us see how the linking power of chlorine varies, by analyzing the four formulas given above.

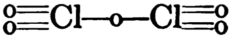
It is evident that the first, Cl_2O, which is analogous to H_2O, has as graphic formula Cl—O—Cl, and that the valence of chlorine is one.

Now for Cl_2O_3. Three atoms of oxygen means six bonds to be divided between two atoms of chlorine. Therefore, each chlorine must take up three bonds of oxygen, giving the graphic formula

$$O{=}Cl{-}O{-}Cl{=}O$$

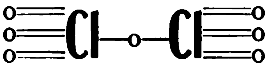
In Cl_2O_3 the valence of chlorine must be three.

In Cl_2O_5 the five oxygen atoms give us ten bonds, so each chlorine must make up five bonds, thus:



and the valence of chlorine is five.

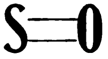
In Cl_2O_7 the seven oxygen atoms mean fourteen bonds, with seven bonds for each chlorine to take up, thus:

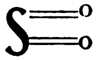


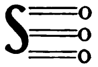
and in this case the valence of chlorine must be seven.

Then, we have three combinations of sulphur, with oxygen:

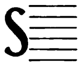
SO, SO_2, and SO_3.

In  the valence of sulphur must be two.

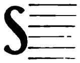
In  " " " four.

In  " " " six.

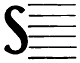
This suggests that the valence of an element varies, and the variation has been explained in this manner: The true valence of an element is its highest. Thus, in sulphur the true valence is six,



In some way two of the "hands" (bonds) become clasped, and just as it is impossible to pick up anything with clasped hands, so those two bonds became useless for linkage purposes and the sulphur atom possesses but four active bonds, as shown below.



Again two more "hands" grasp—two bonds saturate each other, as the term is—and there remain but two active bonds to the sulphur atom, its valence is two, thus,



This fanciful picture is given for what it is worth, and, contrary to this theory, the usual and most stable valence is the lowest.

The valence of an element is expressed in Roman numerals above and to the right of its symbol; thus, chlorine is expressed as Cl^{i}, Cl^{iii}, Cl^{v}, or Cl^{vii} respectively, according as its valence is one, three, five, or seven.

In the table of elements found on the following page not only is the valence and atomic weight of each element given, but the elements are grouped in two columns, according as they are electropositive or electronegative.

These two terms indicate the behavior of the elements when compounds containing them are subjected to the action of a current of electricity.

The subject of electricity is beyond the scope of this work, and here can mention be made only of the fact that electricity is developed by the dynamo, such as can be seen at any electric lighting station, and the battery, such as accompanies every telephone or telegraph instrument.

From every battery two wires emerge, and through these wires pass electricity of different quality, called positive and negative, and the termination of the two wires are called the positive pole and the negative pole respectively.

If we take common salt, sodium chloride, melt it and subject it, while molten, to a current of electricity, at the positive pole of the battery we get the odor of chlorine; while at the negative pole we get metallic sodium.

Now, the electric rule is: "Like electricities repel each other; unlike attract each other," and, since sodium goes to the negative pole, we call it positive; while chlorine, going to the positive pole, is called negative. Accordingly, we see that sodium chloride contains one portion that is positive and another that is negative, and, from this, Berzelius worked out his electromagnetic theory, by which he divided every chemical compound into positive and negative parts, and attempted to explain chemical action by electric influence. But his theory did not stand the test of time, and it has been replaced by the ionic theory (see p. 119) according to which some soluble substances when dissolved in the appropriate fluid are divided into electrically charged particles called ions. The ions that are negatively charged are called *anions;* while the positively charged particles are known as *cations.* Curiously, some of the details of the electron theory outlined on p. 346 resemble the old Berzelius idea. As just mentioned under electrolytic dissociation, the metals are shown to be positive, while the non-metallic elements are negative. The division, however, is purely relative. Thus, when zinc is combined with chlorine it is the positive part of the compound; whereas, when combined with sodium it is found in the negative ion.

ELEMENTAL TABLE

	NEGATIVE −			POSITIVE +		
	Name	*Symbol and valence*	*Atomic weight*	*Name*	*Symbol and valence*	*Atomic weight*
MONADS. (Usually having valence I.)	Chlorine	Cl. I III V VII	35.5	Lithium	Li. I	7
	Bromine	Br. I III V VII	80.0	Sodium	Na. I	23
	Iodine	I. I III V VII	127.0	Potassium	K. I	39
				Copper ("ous" form)	Cu. I	63
				Silver	Ag. I	108
				Mercury ("ous" form)	Hg. I	200
DYADS. (Usually having two bonds—the valence II.)	Oxygen	O. II	16.0	Magnesium	Mg. II	24
	Sulphur	S. II IV VI	32.0	Calcium	Ca. II	40
				Strontium	Sr. II	87
				Barium	Ba. II	137
				Iron ("ous" form)	Fe. II	56
				Copper ("ic" form)	Cu. II	63
				Zinc	Zn. II	65
				Mercury ("ic" form)	Hg. II	200
				Lead	Pb. II	209
				Tin ("ous" form)	Sn. II	119
TRIADS. (Having the valence III, usually.)	Boron	B. III	11.0	Aluminum	Al. III	27
	Nitrogen	N. III V	14.0	Iron ("ic" form)	Fe. III	56
	Phosphorus	P. III V	31.0	Gold	Au. III	196
	Arsenic	As. III V	75.0	Bismuth	Bi. III	207
	Antimony	Sb. III V	120.0	Cerium	Ce. III	140
TETRADS. (Valence of IV.)	Carbon	C. IV	12.0	Tin ("ic" form)	Sn. IV	119
	Silicon	Si. IV	28.0			

Chromium (Cr, at. wt. 52) and manganese (Mn, at. wt. 55), while found in official compounds, are omitted from the table for reasons given on pp. 496 and 486.

Following the theory of variation in valence cited on p. 351, it is seen that the variation should always be by two—I, III, V, VII or II, IV, VI—and facts bear this out; mercury, iron, and copper being the only exceptions in the table just given. The irregular variations of these will be explained later.

The periodic system of elements is the name given the grouping of elements according to their atomic weights. It is beyond the scope of this book to discuss this beautiful theory of Mendelejeff and those desiring information further than the bare statement that "the properties of elements are periodic functions of their atomic weights" (Smith) are referred to the papers suggested in the bibliography at the end of this chapter.

Having considered the subject of chemistry from the standpoint of the individual elements, we can now take up the subject, grouping of elements, thus entering into the domain of chemical compounds.

We have spoken of molecules as the smallest particles of matter existing in a free state, and we mentioned among others the molecule of oxygen. Such an elemental molecule is called a *simple* molecule, in distinction to *compound* molecules; those containing at least two different kinds of elements. Thus, while O_2, S_2, or P_4 are examples of simple molecules, NaCl, K_2SO_4, and $KNaC_4H_4O_6$ are types of compound molecules; and while the simple molecules contain only a small number of atoms—usually two—the number of atoms in a compound molecule are practically unlimited; one complex organic body, hemoglobin, containing over 2000 atoms to the molecule, it is claimed.

Taking up the inorganic compound molecules, we first divide them into two classes—the binary and the ternary compounds.

Binary compounds are those containing two different kinds of elements. Thus, NaCl, KBr, CaO, and Cl_2O_3 are examples of binary compounds.

The naming of binary compounds is simple. We give the name of the positive element first; then the name of the negative element, changing its termination to "ide." Making this clear by illustration, we will take NaCl as the first example. This consists of sodium and chlorine. The table on p. 352 shows that sodium is the positive element and chlorine the negative element of that compound. Accordingly, we call the body sodium chlor*ide*. Remember, as *very important*, that the termination "ide" is characteristic of binary compounds.

In writing binary compounds we place the symbol of the positive element first; then the symbol of the negative element, placing below and to the right of each symbol, in Arabic numerals, the respective number of atoms entering into the molecule. Thus $CaCl_2$ means 1 atom of calcium and 2 atoms of chlorine, making a molecule of calcium chloride.

Before leaving binary compounds, mention must be made of the four acids belonging to this group. These four are HCl (hydrochloric acid); HBr (hydrobromic acid); HI (hydriodic acid); and HFl (hydrofluoric acid); and they are called the halogen or haloid acids. As acids will come in for discussion in Chapter XXIV, these halogen acids will be left for that time. They must be noted here, however, if for no other reason than as exceptions to the nomenclature—to the naming—of binary compounds.

Ternary compounds are those inorganic bodies containing three or more different kinds of elements. The word "ternary," coming from a Latin root meaning "three," would seem to exclude any compounds other than those containing three kinds of elements. However, as there are comparatively few definite inorganic compounds containing more than three different elements, these few are usually included and discussed with the ternary compounds. The naming of ternary compounds is a matter of some complexity, and before discussing this phase of the question it is necessary to explain the formation of ternary compounds.

All ternary compounds are derived indirectly from binary compounds, the oxides, and it is therefore necessary to discuss these important bodies. If we take the various oxides and combine them with water, we get, according as the distinctive element is positive or negative, an acid or a base, as shown by the two following equations:

$$\begin{aligned} \text{Thus, } P_2O_5 + H_2O &= H_2P_2O_6 = 2HPO_3. \\ CaO + H_2O &= CaO_2H_2 = Ca(OH)_2. \end{aligned}$$

By the term "equation," given above, we mean the representation by means of symbolic formulas of how a chemical reaction occurs.

Thus, the first of the two equations given above means that one molecule of phosphoric oxide (P_2O_5) combines with one molecule of water (H_2O) to make two molecules of metaphosphoric acid ($2HPO_3$).

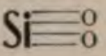
The second means that one molecule of calcium oxide (CaO) combines with one molecule of water (H_2O) to make one molecule of the base, calcium hydroxide ($Ca(OH)_2$).

Details of the writing and the balancing of such equations will be given later (p. 400).

In discussing this matter we will consider, first, the acids and then the bases.

Formation of the Acid Formula.—Going back to the table on p. 352, running down the line of negative elements we find silicon with the valence four.

One atom of silicon with valence four can take up two atoms of oxygen with valence two, as shown in the following graphic formula:



$$\mathrm{Si}{\begin{smallmatrix}=O\\=O\end{smallmatrix}} \quad \text{or } SiO_2.$$

This body is called silicon oxide or silicic oxide. If this oxide combined with water we would get:

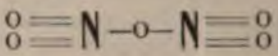
$$\begin{array}{l} \quad SiO_2 \\ \underline{H_2\ \ O\quad} \\ H_2SiO_3 \qquad \text{Silicic Acid.} \end{array}$$

In another form, $SiO_2 + H_2O = H_2SiO_3$.

It will be noticed that in this oxide and the derived acid the word silicon is changed to silic*ic*.

Suppose we consider the two oxides of nitrogen which combine with water. Looking at the table on p. 352, we find the valence of nitrogen three and five; therefore the oxides must be

$$O{=}N{-}O{-}N{=}O \quad \text{or } N_2O_3 \text{ and}$$



$$\begin{smallmatrix}O\\O\end{smallmatrix}{\equiv}N{-}O{-}N{\equiv}\begin{smallmatrix}O\\O\end{smallmatrix} \quad \text{or } N_2O_5$$

The linkage of the nitrogen and of the oxygen in these two cases occurs in a manner precisely the same as the linkage between oxygen and chlorine of valence three and five, as shown on p. 351. In naming these two oxides of nitrogen both cannot be nitr*ic* oxide, so we apply that name to the one in which nitrogen shows the highest valence, calling the other, the one in which nitrogen shows the valence three, nitr*ous* oxide.

Adding water to these, we get the corresponding acids: thus—

(*a*) N_2O_3 (nitr*ous* oxide) $+ H_2O = H_2N_2O_4 = 2HNO_2$ (nitr*ous* acid).
(*b*) N_2O_5(nitr*ic* oxide) $+ H_2O = H_2N_2O_6 = 2HNO_3$ (nitr*ic* acid).

These two equations can be expressed in words as follows:

(*a*) One molecule of nitrous oxide plus one molecule of water gives two molecules of nitrous acid.

(*b*) One molecule of nitric oxide plus one molecule of water gives two molecules of nitric acid.

In other words, with these oxides of nitrogen the molecule of the oxide does not blend with the molecule of water to make one molecule of the acid, as was the case in the formula of silicic acid, but *two* molecules result from the combination.

As the symbolic formula expresses the contents of a molecule, the formula of nitrous acid is HNO_2 and the formula of nitric acid is HNO_3.

Looking up sulphur, we find it has three valences, and, therefore, yields three oxides, SO, SO_2, and SO_3. SO_3 we call sulphur*ic* oxide; SO_2, sulphur*ous* oxide; and SO we call *hypo*sulphur*ous* oxide, the prefix "hypo" meaning "under."

Let us see how these three oxides form acids.

SO (*hypo*sulphur*ous* oxide) $+ H_2O = H_2SO_2$ (*hypo*sulphur*ous* acid).
SO_2 (sulphur*ous* oxide) $+ H_2O = H_2SO_3$ (sulphur*ous* acid).
SO_3 (sulphur*ic* oxide) $+ H_2O = H_2SO_4$ (sulphur*ic* acid).

So when we have three acids from one negative element, the name of the negative element in which that element acts with the highest valence is given the termination "*ic;*" the termination in the one in which the element acts with the next lower valence is "*ous;*" while the one in which the element acts with the lowest valence is given the prefix "*hypo*" and the termination "*ous.*"

As noted on p. 350, four oxides of chlorine yielding acids are known: Cl_2O, Cl_2O_3, Cl_2O_5, and Cl_2O_7. In naming these, the one with the lowest valence of chlorine is called "*hypo*chlor*ous*;" the next, "chlor*ous*;" and the next, "chlor*ic*," just as in the preceding. This leaves the fourth to be named, and it is given the prefix "*per*" and the termination "*ic*"—"*per*chlor*ic*." These four oxides yield four acids, as follows:

Cl_2O (*hypo*chlor*ous* oxide) $+ H_2O = H_2Cl_2O_2 = 2HClO$ (*hypo*chlor*ous* acid).
Cl_2O_3 (chlor*ous* oxide) $+ H_2O = H_2Cl_2O_4 = 2HClO_2$ (chlor*ous* acid).
Cl_2O_5 (chlor*ic* oxide) $+ H_2O = H_2Cl_2O_6 = 2HClO_3$ (chlor*ic* acid).
Cl_2O_7 (*per*chlor*ic* oxide) $+ H_2O = H_2Cl_2O_8 = 2HClO_4$ (*per*chlor*ic* acid

This completes the theoretic formation and naming of acids; the summary of nomenclature being:

If there is one oxyacid from an element it has the termination "*ic.*"
If there are two, the higher in valence is "*ic.*"
the lower in valence is "*ous.*"
If there are three, the highest in valence is "*ic.*"
the middle in valence is "*ous.*"
the lowest in valence is "*hypo—ous.*"
If there are four, the lowest in valence is "*hypo—ous.*"
the next higher in valence is "*ous.*"
the next higher in valence is "*ic.*"
the highest in valence is "*per—ic.*"

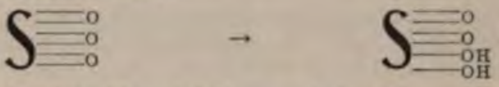
Remember, this method of nomenclature applies only to oxyacids—those acids which contain oxygen.

The four haloid acids have their specific names—hydrochloric, hydrobromic, etc., and do not enter into this category. Do not confuse *hydrochloric* with *chloric* acid. Hydrochloric acid is a binary compound, HCl, while chloric acid is ternary—an oxyacid—$HClO_3$.

It may be well to emphasize that the above explanation of the formation of acids is given merely with the view of teaching the student the writing of formulas, and it is necessary to warn the reader against assuming the conclusion that the practical manufacture of the chemicals whose formulas are thus worked out of necessity follows the same line here suggested. While it is true that sulphuric acid is made by treating sulphuric oxide with water, silicic acid cannot be formed by direct combination of silicic oxide (sand) and water. Again, it might be mentioned that frequently some of the compounds spoken of familiarly when discussing formula writing may be too unstable to exist. This is true of several oxides of chlorine and of iodine.

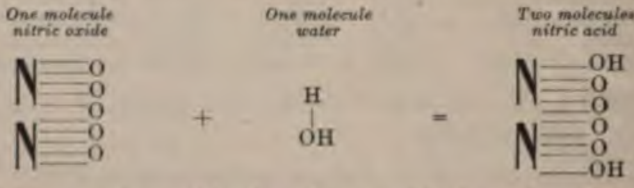
In working out the theoretic formation of the acids given above, the graphic formula of the oxide has been given, followed by the mere statement that the acid is formed by adding water to the oxide. The question that might arise is, How is it possible to add a molecule of water to a saturated compound? In the group SO_3 each of the six bonds of the sulphur are taken up by oxygen, so where can the two atoms of hydrogen and one of oxygen be attached?

The answer is very simple, for when water (H_2O) is brought in contact with sulphuric oxide (SO_3), the latter arranges with the water to the new groupings here shown:

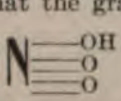


the water breaking into H and OH; one of the O atoms of SO_3 breaking loose from the double union with sulphur and uniting with the free H from the water (forming OH), while the OH group from the water attaches itself to the free sulphur bond, and we get the compound $SO_2(OH)_2$ or H_2SO_4, sulphuric acid, containing two hydroxyls (the radical mentioned on p. 570).

It might be interesting to express graphically the transition of one molecule of nitric oxide into two molecules of nitric acid, as described above.



It will be seen from this that the graphic formula of nitric acid is



that is, to the atom of nitrogen there are attached two atoms of oxygen and one hydroxyl group.

Formation of the Formulas of Bases.—Bases, with the exception of ammonia and its organic derivatives, which we will discuss in due course of time, represent the oxygen and hydrogen compounds of a positive element, and can be derived in exactly the same way as the acids have been from the negative elements—by adding water to the oxides; only in the case of bases the process is much simpler.

In glancing over the positive elements on p. 352, it will be noticed that all these elements, save mercury, iron, and copper, usually exhibit but one valence, and, accordingly, each element usually yields but one base. The nomenclature is much simplified by this fact, bases being named by placing the name of the characteristic element first, followed by the word "hydroxide".

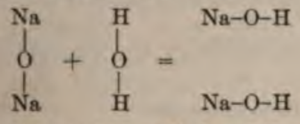
Let us summarize by a few general examples:

Na_2O (sodium oxide) $+ H_2O = Na_2O_2H_2 = 2NaOH$ (sodium hydroxide).
CaO (calcium oxide) $+ H_2O = CaO_2H_2 = Ca(OH)_2$ (calcium hydroxide).
Fe_2O_3 (ferric oxide) $+ 3H_2O = Fe_2O_6H_6 = 2Fe(OH)_3$ (ferric hydroxide).

In the above equations the end formula, whenever possible, has been reduced to its simplest form. Thus, $Na_2O_2H_2$, like $H_2N_2O_4$ of p. 355, can be divided by two, and in truth the molecule of sodium hydroxide is $NaOH$ and not $Na_2O_2H_2$. Again, note that a large figure placed at the commencement of a formula multiplies every element following it by that number; thus $2NaOH$ means $Na_2O_2H_2$; $2HNO_2$ is the same as $H_2N_2O_4$ ($O_2 \times 2$ equals O_4).

It will be seen in the case of calcium hydroxide that CaO_2H_2, containing as it does but one atom of calcium, constitutes one molecule. In such cases, however, it is considered neater to inclose the oxygen and hydrogen in brackets, with the number of atoms outside the brackets. Thus, CaO_2H_2 is usually expressed as $Ca(OH)_2$. A small figure outside the brackets multiplies each element within the brackets, even as a large figure in front of the formula multiplies every element following it.

Graphically, these hydroxides may be expressed with equal ease as hydroxyl derivatives, each bond of metal taking one OH group, thus:



$$\begin{matrix} Na \\ | \\ O \\ | \\ Na \end{matrix} + \begin{matrix} H \\ | \\ O \\ | \\ H \end{matrix} = \begin{matrix} Na{-}O{-}H \\ \\ \\ \\ Na{-}O{-}H \end{matrix}$$

It is customary to make a slight difference in the writing of acids and bases. In writing acids, we place the hydrogen atoms first, then the characteristic element, and finally the oxygen atoms. In bases, on the contrary, the characteristic element comes first, followed by the hydroxyl groups. This is a mere matter of form, the only reason why the two classes of bodies are so differentiated being because it affords a convenient method of distinguishing acid and basic formulas.

It is wise, however, not to get bound down to rigid rules. Different books have different ways of writing formulas; for instance, sulphuric acid can be written $SO_2(OH)_2$ as well as H_2SO_4.

Considerable mention has been made on preceding pages of acids and bases without giving any idea what these bodies really are. The theoretic consideration of them just given is very important, but it does not represent real practical conditions. Acids and bases had first to be known before theories regarding them were evolved, and it is of greatest importance that they should be known when met with.

The following definitions should be carefully studied:

An *acid* is a substance which turns *blue* litmus-paper *red* and combines with bases to form salts.

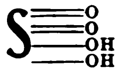
A *base* is a substance which turns *red* litmus-paper *blue* and combines with acids to form salts. And, finally,

A *salt* is the product of the combination of an acid and a base.

Litmus-paper is an article of commerce made by dipping porous paper in a decoction of litmus, a sort of lichen. A drop of acid (always to be applied in diluted form) will make a red spot on blue litmus-paper, and likewise a drop of diluted alkali (as bases are called) will make a blue spot on red litmus-paper.

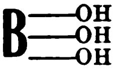
Electrolytic conception of acids, bases and salts, as expressed by physical chemists, is different from the definitions just given, since approached from the standpoint of the ionic theory. (See p. 352.) According to this viewpoint, acids are those substances which give hydrogen ions (hydrions) in aqueous solution; bases under the same conditions give hydroxyl ions (hydroxidions) while salts give ions other than hydrions and hydroxidions. Thus an acid like H_2SO_4 dissociates in solution into two positive hydrogen ions and one negative SO_4 ion; a base like KOH dissociates into one positive potassium ion and one negative OH ion; while a salt like K_2SO_4 dissociates into two positive potassium ions and one negative SO_4 ion.

The three classes, acids, bases, and salts, cover the entire domain of ternary compounds. Before speaking of salts, mention must be made of another point concerning acids. We have just seen that sulphuric acid may be written—



$$\mathrm{S}\begin{array}{l}=\mathrm{O}\\=\mathrm{O}\\-\mathrm{OH}\\-\mathrm{OH}\end{array}$$

In other words, as a sulphur atom with two oxygen atoms and two hydroxyl groups attached. If we look up the formula of boric acid, we find it to be H_3BO_3 or, graphically,



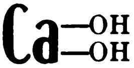
$$\mathrm{B}\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\end{array}$$

In this, each bond of the characteristic atom is taken up by a hydroxyl, and such an acid is called an "ortho" acid. Almost all bases are "ortho," having as many hydroxyls as bonds of the characteristic element, and thus we find—

Sodium hydroxide

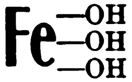
Na—OH

Calcium hydroxide



$$\mathrm{Ca}\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\end{array}$$

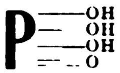
Ferric hydroxide



$$\mathrm{Fe}\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\end{array}$$

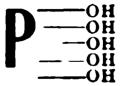
but with acids it is different, and of the oxyacids, *boric acid* is the only official ortho acid.

There is an official acid called orthophosphoric acid (H_3PO_4), but it is not a true ortho-acid in the sense expressed above. Its graphic formula is—



$$\mathrm{P}\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\\=\mathrm{O}\end{array}$$

while true ortho-phosphoric acid should be



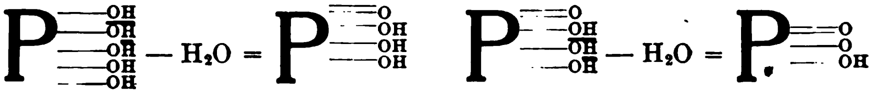
$$\mathrm{P}\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\\-\mathrm{OH}\end{array}$$

Acids not having all the bonds of the characteristic element taken up by hydroxyl groups are called *meta*-acids, and, accordingly, H_3PO_4 should be classed among the meta-acids.

The original idea of ortho- and meta- combinations was that when two kinds of salts of the same acid were known, the one containing the most metal was called the ortho-salt, while the other was called the meta-salt. Thus, the sodium salt of H_3PO_4 was called orthophosphate of soda, while the sodium salt of HPO_3 was called metaphosphate of soda.

The difference between the three phosphoric acids, H_5PO_5, H_3PO_4, and HPO_3, is simply a loss of water.

It appears that usually the characteristic element cannot carry many hydroxyl groups, and these are parted with by the throwing off of water, as represented in the following graphic sketch, in each formula of which the hydrogen and oxygen, thrown off as water, are underscored:



$H_5PO_5 - H_2O = H_3PO_4$ $H_3PO_4 - H_2O = HPO_3$

H_5PO_5 H_3PO_4 H_3PO_4 HPO_3

SALTS

Salts are solids, neutral to test-paper, affecting neither the red nor the blue of litmus. Of course, there are exceptions; but this much can be usually stated regarding them. As to the naming of a salt, we place first the name of the metal (the base; the positive element), then the name of the acid, the termination of which is changed to "ate," if we are dealing with an "ic" acid; and to "ite," if it comes from an "ous" acid. This is shown clearly in the names of the oxyacids of chlorine.

Hypochlor*ous* acid gives hypochlor*ites*.
Chlor*ous* acid gives chlor*ites*.
Chlor*ic* acid gives chlor*ates*.
Perchlor*ic* acid gives perchlor*ates*.

The salts of the halogen acids do not come under this method of nomenclature. Such salts are binary compounds, and are given the termination "ide;" thus, hydrochloric acid yields chlorides, hydrobromic acid yields bromides, hydriodic acid yields iodides. The alkaloidal salts of these acids, are, however, called hydrochlorides, hydrobromides and hydriodides.

The formation of salts is governed by valence, just as is the origin of all other compounds, and to write the formulas of salts intelligently it is essential to know the valence expressed in the table on p. 352.

We have given as the definition of valence "the relative combining power of elements." Valence, however, means more than this, and when we say that the valence of sodium is one, we not only mean that an atom of it can combine with one atom of chlorine to form a molecule of sodium chloride, but also (what is the same thing expressed differently) one atom of it can *replace* one atom of hydrogen in hydrochloric acid (HCl) to form the molecule of sodium chloride. So valence not only means relative combining power, but also the relative power of a metal to replace the hydrogen of an acid.

A few examples may perhaps better explain this.

Let us take sodium, with the valence one. One atom can replace one atom of hydrogen in an acid.

Nitric acid, HNO_3, has one atom of hydrogen; this can be replaced by an atom of sodium, when we get $NaNO_3$, sodium nitrate. Sulphuric acid, H_2SO_4, has two atoms of replaceable hydrogen; therefore, two atoms of sodium are needed, when we get Na_2SO_4, sodium sulphate.

Now for the combinations of *calcium*, valence two, which means that one atom of calcium can replace two atoms of hydrogen in an acid.

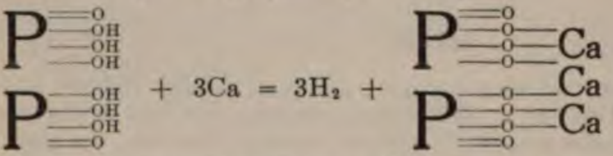
Nitric acid, HNO_3, has one atom of hydrogen; calcium requires two; accordingly, we take one atom of calcium and two molecules HNO_3, thus:

$$Ca^{II} + \begin{matrix}HNO_3\\HNO_3\end{matrix} = H_2 + Ca\begin{matrix}-NO_3\\-NO_3\end{matrix}$$

replacing the two hydrogen atoms by one Ca, forming $Ca(NO_3)_2$, calcium nitrate.[1]

Sulphuric acid, H_2SO_4, has two atoms of hydrogen. These can be replaced by one atom of calcium, when we get $CaSO_4$, calcium sulphate.

Phosphoric acid, H_3PO_4, has three replaceable atoms of hydrogen; calcium requires two. This complicates matters and we had better write the equation graphically:



$Ca_3(PO_4)_2$
Calcium phosphate.

the reaction occurring between three atoms of calcium and two molecules of phosphoric acid, the six hydrogen atoms of which are replaced by the three calcium atoms.

As the last example, let us take bismuth, valence three; one atom of bismuth being able to replace three atoms of hydrogen in an acid.

Nitric acid, HNO_3, has one hydrogen; so to combine with bismuth three molecules of nitric acid are necessary, thus:

$$Bi^{III} + \begin{matrix}HNO_3\\HNO_3\\HNO_3\end{matrix} = H_3 + Bi\begin{matrix}-NO_3\\-NO_3\\-NO_3\end{matrix} \quad \begin{matrix}Bi(NO_3)_3\\ \text{Bismuth nitrate.}\end{matrix}$$

Sulphuric acid, H_2SO_4, has two atoms of hydrogen; bismuth requires three; therefore combination occurs between three molecules of the acid and two atoms of bismuth, thus:

$$\begin{matrix}Bi^{III}\\Bi^{III}\end{matrix} + \begin{matrix}H_2SO_4\\H_2SO_4\\H_2SO_4\end{matrix} = 3H_2 + \begin{matrix}Bi\\Bi\end{matrix}\begin{matrix}=SO_4\\=SO_4\\=SO_4\end{matrix} \quad \begin{matrix}Bi_2(SO_4)_3\\ \text{Bismuth sulphate.}\end{matrix}$$

Phosphoric acid, H_3PO_4, has three atoms of hydrogen; bismuth requires three, so the combination should be:

$$Bi + H_3PO_4 = H_3 + BiPO_4 \quad \text{Bismuth phosphate.}$$

To sum up the important study of the writing of formulas of salts:

Halogen Salts.—These follow the general rule for binary compounds. Remember that all official compounds the name of whose negative element ends in "ide" are binary, and then follow the general rule for binary formulas given on p. 353; the process being merely a matter of relative valence. As to writing binary compounds, look up the valence of the positive and negative elements of the compound, and combine these in just such proportions that each will furnish the same number of bonds; viz.:

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[1] In this and other replacing equations found in this chapter, the liberation of hydrogen need not be taken too literally. Metallic calcium plus the appropriate acid may liberate hydrogen, but the reaction is too violent to be practical. In general manufacturing the oxide or carbonate of the first and second group of metals is usually employed.

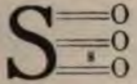
Valences similar,	the elemental union is	atom for atom.
Valences II and III,	" "	3 atoms of II to 2 atoms of III.
Valences II and IV,	" "	2 atoms of II to 1 atom of IV.
Valences II and V,	" "	5 atoms of II to 2 atoms of V.
Valences II and VI,	" "	3 atoms of II to 1 atom of VI.
Valences II and VII,	" "	7 atoms of II to 2 atoms of VII.

Combinations of the valence I with the valence II and VII are so simple that they need not be given. Until the student becomes expert, it is better to work out formulas by the graphic means described on p. 351.

In writing out the empirical formulas of the binary compounds, remember that the symbol of the positive element comes first, then that of the negative, with the number of atoms of each below and to the right of the respective symbols.

Ternary Salts.—In writing a formula of a ternary salt, we first must know the formula of the acid from which it is derived, and this is worked out from the formula of the oxide, which in turn is figured by valence—by the regular rule for the writing of binary formulas. An example can best illustrate this.

We want to know the formula of sodium sulphate and do not know either the formula of sulphuric acid nor of sulphuric oxide. Referring to table of elements on p. 352, we find the valence of sulphur is II, IV, and VI. We are working on sulphuric compounds, and the valence of sulphur in these is its highest, VI, and, graphically, we sketch the oxide.



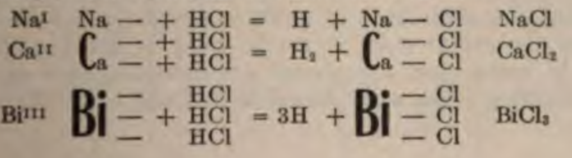
SO_3
Sulphuric oxide.

To make this into sulphuric acid, water is added, by the following reaction:

$$SO_3 + H_2O = H_2SO_4.$$

Thus, learning that the formula of sulphuric acid is H_2SO_4, and remembering that each atom of hydrogen removed from the acid in making a salt calls for one bond of the replacing metal, we now look at the *replacing capacity*—the valence—of the metal. We find that sodium has the valence one—that one atom of it can replace but one atom of hydrogen in an acid. As sulphuric acid has two atoms of hydrogen, to replace these, two atoms of sodium will be needed, and by this reasoning we learn that the formula of sodium sulphate is Na_2SO_4. All this was fully explained on p. 360.

If deemed preferable, the haloid salts—the salts of hydrochloric, hydrobromic, hydriodic, and hydrofluoric acids—may be worked out by this idea of replacement of hydrogen in an acid by a metal, as the following sketching of the formulas of chlorides will show:

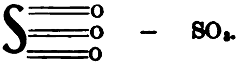


$$\mathrm{Na^{I}}\quad \mathrm{Na}- + \mathrm{HCl} = \mathrm{H} + \mathrm{Na}-\mathrm{Cl}\quad \mathrm{NaCl}$$

$$\mathrm{Ca^{II}}\quad \mathrm{Ca}\begin{matrix}-+\mathrm{HCl}\\-+\mathrm{HCl}\end{matrix} = \mathrm{H_2} + \mathrm{Ca}\begin{matrix}-\mathrm{Cl}\\-\mathrm{Cl}\end{matrix}\quad \mathrm{CaCl_2}$$

$$\mathrm{Bi^{III}}\quad \mathrm{Bi}\begin{matrix}-\\-\\-\end{matrix} + \begin{matrix}\mathrm{HCl}\\\mathrm{HCl}\\\mathrm{HCl}\end{matrix} = 3\mathrm{H} + \mathrm{Bi}\begin{matrix}-\mathrm{Cl}\\-\mathrm{Cl}\\-\mathrm{Cl}\end{matrix}\quad \mathrm{BiCl_3}$$

This explanation can be condensed into the following table of formula writing. If we want the formula of a ternary salt—say sodium sulphate—it can be worked out by answering the following questions:

QUESTION	ANSWER Applied to the type, sodium sulphate
1. Of what acid is the compound a salt?	A sulph*ate* is a salt of sulphur*ic* acid, "ic" acids giving "ate" salts.
2. From what oxide is this acid derived?	From sulphur*ic* oxide, the name of the oxide being always that of the acid.
3. What is the characteristic element in this oxide?	Sulphuric acid must come from the element sulphur.
4. What is the valence of this element?	II, IV, and VI, as shown on p. 352.
5. What is the valence of this element in the oxide above mentioned?	"ic" oxide means that oxide showing the highest valence of the element, when that element has three or less valences. Hence in sulphuric oxide sulphur must have the valence VI.
6. What is the graphic formula of this oxide?	One atom of sulphur with valence VI takes three atoms of oxygen (valence II) for saturation, thus:  $S{=}O_3$ – SO_3.
7. How is the acid derived from this oxide?	By addition of water, thus, $SO_3 + H_2O = H_2SO_4$.
8. What, then, is the formula of the acid?	H_2SO_4.
9. What is the valence of the metal in the salt?	The table on p. 352 says sodium has the valence I.
10. What does this mean?	That one atom of sodium can replace one atom of hydrogen in an acid.
11. How many atoms of replaceable hydrogen are there in the acid in question?	In H_2SO_4 there are two atoms of replaceable hydrogen.
12. Then how many atoms of the metal are needed to make a molecule of the salt in question?	The two atoms of hydrogen in H_2SO_4 need two atoms of sodium to replace them.
13. What, then, will be the formula of the salt?	Its formula will be Na_2SO_4.

By such reasoning, with the aid of the table on p. 352, practically every formula of a ternary salt can be worked out.

The salts produced as just described—by replacing all the hydrogen of an acid by a metal—are called *normal salts.*

Thus, when the two atoms of hydrogen in sulphuric acid (H_2SO_4) are replaced by two atoms of sodium, we obtain Na_2SO_4—normal sodium sulphate.

It is possible, however, to replace only one atom of hydrogen in the above acid by one atom of a monad metal, and if sodium is the metal, we obtain $NaHSO_4$ (sodium bisulphate), one hydrogen still remaining in the compound. This atom of hydrogen still exerts its acid properties, and such salts usually turn blue litmus red, and are, therefore, called *acid salts.* Why these salts are given the prefix "bi," as *bi*sulphate, *bi*tartrates, etc., will be explained later.

On treating these *acid salts,* such as potassium bitartrate ($KHC_4H_4O_6$), with the hydroxide or carbonate of another metal (and be it here said that in practice the metal itself is rarely used in making these salts, in many cases it being too dangerous a procedure), the other metal replaces the remaining atom of replaceable hydrogen, thereby forming a *double salt.*

Thus, replacing the hydrogen of $KHC_4H_4O_6$ by an atom of sodium, we obtain potassium and sodium tartrate ($KNaC_4H_4O_6$), or Rochelle salt.

In due course of time (p. 573) it will be explained why only part of the hydrogen of an organic acid is replaceable by a metal.

Besides the normal, acid, and double salts just mentioned, there is a class of salts called *basic salts*. In the acid salts there is predominance of the acid portion; in the basic salts there is a deficiency of such. These basic salts will be more thoroughly considered later. (See p. 513.) So here suffice it to state that most of the "sub" preparations, as bismuth *sub*nitrate, iron *sub*sulphate, etc., are basic salts.

CHEMICAL ARITHMETIC

The pharmaceutic applications of atomic and molecular weights described on pp. 348 and 349 are manifold.

Thus, through molecular weights we are able to *estimate the amount of water of crystallization* in a chemical (p. 149).

For instance, let us figure out the percentage of water of crystallization in the formerly official sodium carbonate.

The formula of this body is $Na_2CO_310H_2O$, which means a molecular weight of 286 as the following reckoning will show:

Atomic weight of Na is 23 $Na_2 = 2 \times 23 = 46$
Atomic weight of C " 12 $C = 1 \times 12 = 12$
Atomic weight of O " 16 $O_3 = 3 \times 16 = 48$
Atomic weight of H " 1 $10H_2 = 20 \times 1 = 20$
Atomic weight of O " 16 $10O = 10 \times 16 = 160$
286

The molecular weight of $Na_2CO_310H_2O$ is 286, and of this, 180 parts (20 + 160) represent the ten molecules of water of crystallization. What per cent. of 286 is 180?

This is easily $^{180}/_{286}$ of 100 per cent., or 63 per cent., and we thus learn that 63 per cent. of crystalline sodium carbonate is water.

Again, the knowledge of molecular weights is imperative in estimating the *proportional weight of substances entering into a chemical reaction.*

For instance, let us calculate the amount of calcium carbonate and hydrochloric acid needed to make calcium chloride.

Such a problem is solved as follows:

We first figure out what the reaction would be, and express same by the appropriate equation.

In this case it is:

$CaCO_3$	+	$2 HCl$	=	$CaCl_2$	+	CO_2	+	H_2O
1 molecule calcium carbonate.		2 molecules hydrochloric acid.		1 molecule calcium chloride.		1 molecule carbon dioxide.		1 molecule water.

What are the molecular weights of these several bodies?

$CaCO_3$.
At. wt. of Ca = 40. $Ca = 1 \times 40 = 40$
At. wt. of C = 12. $C = 1 \times 12 = 12$
At. wt. of O_3 = 16. $O_3 = 3 \times 16 = 48$
Mol. wt. $CaCO_3 = 100$

HCl.
At. wt. of H = 1. $H = 1 \times 1 = 1$
At. wt. of Cl = 35.5. $Cl = 1 \times 35.5 = 35.5$
Mol. wt. of HCl = 36.5
Hence 2 molecules HCl = 73.0

$CaCl_2$
$Ca = 1 \times 40 = 40$
$Cl_2 = 2 \times 35.5 = 71$
Mol. wt. $CaCl_2 = 111$

CO_2
$C = 1 \times 12 = 12$
$O_2 = 2 \times 16 = 32$
Mol. wt. $CO_2 = 44$

H_2O
$H_2 = 2 \times 1 = 2$
$O = 1 \times 16 = 16$
Mol. wt. $H_2O = 18$

To write equation again:

$$\begin{array}{ccccccccc} CaCO_3 & + & 2HCl & = & CaCl_2 & + & CO_2 & + & H_2O \\ 100 & & 73 & & 111 & & 44 & & 18 \end{array}$$

This summed up means:

	100 Gm. absolute calcium carbonate	Give 111 Gm. calcium chloride.
and	73 " " hydrochloric acid	44 " carbon dioxide.
		18 " water.
	173 Gm.	173 Gm.

Observe that we obtain exactly the same number of grammes of new substances as the total amount of material with which we started in. In other words, in chemical reactions matter is not lost, but merely rearranged. (Law of conservation of matter.)

It is scarcely necessary to say that the amounts given in the above equation are merely proportional, that in place of 100 grammes and 73 grammes given above, we could put 100 pounds and 73 pounds; 100 ounces and 73 ounces; or 100 tons and 73 tons. All that is essential is that quantities of calcium carbonate and hydrochloric acid be in the proportion of 100 to 73.

Let us carry out several modifications of this idea:

(*a*) Suppose the example was: "How much calcium chloride can be made from 1 pound of calcium carbonate?"

From above equation we see that 100 pounds calcium carbonate give 111 pounds calcium chloride. We therefore reason thus:

If 100 pounds $CaCO_3$ give 111 pounds $CaCl_2$, then 1 pound $CaCO_3$ will give $\frac{1}{100}$ of 111 pounds $CaCl_2$, or 1.11 pounds $CaCl_2$.

The same reasoning expressed in proportion reads:

$$100 : 111 :: 1 : x$$

$$x = \frac{111 \times 1}{100} \text{ equals } 1.11.$$

(*b*) Suppose the question was reversed, and read: "How many ounces of calcium carbonate and of absolute hydrochloric acid are needed to make 60 ounces of calcium chloride?"

Since this question asks quantities of the two ingredients, it is in reality two examples, and we must solve each separately.

From the above equation we learn:

100 ounces calcium carbonate and 73 ounces absolute hydrochloric acid make 111 ounces calcium chloride.

Applying this truth to the case under consideration, we reason—

If to make 111 ounces $CaCl_2$ we need 100 ounces $CaCO_3$, then to make 60 ounces $CaCl_2$ we will need $\frac{60}{111}$ times 100 ounces $CaCO_3$,

or $\frac{6000}{111}$ ounces $CaCO_3$,

or 54 + ounces $CaCO_3$.

Or expressed in proportion:

$$111 : 100 :: 60 : x$$

$$x = \frac{100 \times 60}{111} \text{ equals } 54 +.$$

The second part of the example is solved by similar reasoning, viz.:

If to make 111 ounces $CaCl_2$ we need 73 ounces absolute HCl, then to make 60 ounces $CaCl_2$ we need $^{60}/_{111}$ times 73 ounces HCl, or $^{4380}/_{111}$ ounces HCl, or 39.46 ounces absolute HCl.

Or expressed in proportion:

$$111 : 100 :: 73 : x$$

$$x = \frac{100 \times 73}{111} \text{ equals } 39.46.$$

(*c*) The figures just given suggest a problem of simple proportion which can be best considered here.

It is seen that the answer just given is 39.46 ounces absolute (100 per cent.) hydrochloric acid. Now, 100 per cent. hydrochloric acid is a gas, and what we commonly call hydrochloric acid is a solution of this gas in water, the hydrochloric acid directed by the pharmacopœia being a solution containing 31.9 per cent. by weight of the gas (p. 392).

Now, suppose the above example asked: "How much hydrochloric acid U.S.P. is needed to make 60 ounces calcium chloride?"

We have just seen that to make 60 ounces $CaCl_2$ 39.46 ounces 100 per cent. HCl is required. Now, if we use the weaker 31.9 per cent. acid, it will require a proportionally greater quantity, and indeed $^{1000}/_{319} \times$ 39.46 ounces, or $^{39460}/_{319}$ ounces, or 123.7 ounces of 31.9 per cent. hydrochloric acid.

The amount is reasoned out as follows: This part of the problem consists of a combination of alligation and proportion. If we wish to dilute 100 per cent. acid to a 31.9 per cent. acid we know (see page 59) we must dilute 31.9 ounces of the 100 per cent. with enough water to make 100 ounces and even so in our problem each 31.9 ounces of 100 per cent. acid must be replaced by 100 ounces of 31.9 per cent. acid. However, the amount of 100 per cent. acid called for in our problem is 39.46 ounces and this will, of course, mean a proportionally larger amount of 31.9 per cent. acid; that is, if for 31.9 ounces of the 100 per cent. acid we must use 100 ounces of 31.9 per cent. acid; then for 39.46 ounces of 100 per cent. and we must use $^{39.46}/_{31.90}$ times 100 ounces or 123.7 ounces as shown above. The equation of proportion would be $31.9 : 100 :: 39.46 : \times.\ \times = 123.7$.

(*d*) In the same way we can estimate the amounts of elements combining to form a compound.

Suppose the question is: "How many grammes of zinc and of iodine are needed to make 100 grammes of zinc iodide?"

The question in this case runs as follows:

$Zn + I_2 = ZnI_2$
Atomic weight of zinc, 65 $Zn = 1 \times 65 = 65$
Atomic weight of iodine, 126 $I_2 = 2 \times 126 = 252$

Molecular weight of $ZnI_2 = 317$

Rewriting the equation:

$$\begin{matrix} Zn & + & I_2 & = & ZnI_2 \\ 65 & & 252 & & 317. \end{matrix}$$

This means:

To make 317 Gm. ZnI_2 we need 65 Gm. of zinc and 252 Gm. of iodine. Then to make 100 Gm. ZnI_2 we need $^{100}/_{317}$ times 65 Gm. of zinc and $^{100}/_{317}$ times 252 Gm. iodine, or 20.5 Gm. of zinc and 79.4 Gm. of iodine.

Or by proportion:

As to zinc, $317 : 65 :: 100 : x.\ x = \frac{65 \times 100}{317} = 20.5.$

As to iodine, $317 : 252 :: 100 : x.\ x = \frac{252 \times 100}{317} = 79.4.$

Lastly, the knowledge of molecular weights is essential in quantitative analysis, both gravimetric and volumetric. This phase of the question will be left until Chemical Analysis is considered in Chapter LIV.

The writing and balancing of chemical equations, such as those given above, will be explained later (p. 400).

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CHAPTER XXIII

THE NEGATIVE ELEMENTS AND THEIR COMPOUNDS

On p. 352 we learned that the elements were roughly divided into the two classes, the negative elements and the positive elements, according to their behavior when submitted to electrolytic action. We have also seen that the hydroxides of the negative elements are called acids, the hydroxides of the positive elements are called bases, while the union of the acids and bases results in a class of compounds called salts.

The salts, along with the bases, will be considered under the metal they contain, and the acids will be considered in the next chapter, as it is advisable, before proceeding to a consideration of the official acids, to study the negative elements from which the important acids are derived, as well as those recognized by the pharmacopœia.

The negative elements are also called the non-metallic elements, or metalloids. The non-metals rarely possess a metallic appearance, are usually poor conductors of electricity, and combine with hydrogen to form gaseous bodies.

A list of the negative elements of importance in pharmacy is found on p. 352, while the following table shows those recognized by the pharmacopœia either as the free element or in combination other than in acids or in salts. In this list the negative metals, arsenic and antimony, are not mentioned, since their analytic behavior groups them among the metals, and they can there be more profitably discussed.

Oxygen (O):
Water, H_2O.
Distilled water, H_2O.
Sterilized distilled water, H_2O.
Solution of hydrogen dioxide (containing 3 per cent. of H_2O_2).

Chlorine (Cl):
Chlorinated lime (containing 35 per cent. available chlorine).
Solution of chlorinated soda (containing 2.5 per cent. available chlorine).

Iodine (I):
Tincture of iodine (containing about 7 per cent. iodine).
Compound solution of iodine (containing about 5 per cent. iodine).
Ointment of iodine (containing 4 per cent. iodine).

Sublimed sulphur (S):
Washed sulphur.
Precipitated sulphur.

Nitrogen monoxide (N_2O):
Phosphorus (P).
Pills of phosphorus ($6/10$ of 1 milligramme to a pill).
Wood charcoal (more or less pure carbon).
Boric acid (H_3BO_3).
Purified siliceous earth (a form of SiO_2):

Hydrogen is not recognized by the U.S.P., but is worthy of notice at this place.

Hydrogen is made in pharmacy by treatment of zinc or other metals with sulphuric acid, and the details of the manufacture will be given later (see p. 479). In commerce many other cheaper methods are employed. It is a colorless, odorless, and tasteless gas, and is interesting as being the lightest known substance. By reason of this fact it is chosen by chemists as the standard of atomic weight and of a large number of other chemical and physical measurements.

OXYGENIUM—Oxygen

(Oxygen)

It contains not less than 95 per cent. by volume of O (16). For convenience it is usually compressed in metal cylinders.

Summarized Description:
Colorless, odorless, tasteless gas; soluble in 34 volumes of water and 3.6 volumes of alcohol. For details see U.S.P., p. 308. For *tests for identity*, for *impurities* (carbon dioxide, halogens, acids and bases) and for *assay*, see U.S.P., p. 308 and also below.

Remarks.—Oxygen, while used a number of years in medicine is now admitted for the first time into the United States Pharmacopœia. It can be made by treating potassium chlorate alone or preferably a mixture of that chemical with manganese dioxide; the latter substance being added to prevent too rapid evolution of the gas. A modern method of extemporaneous preparation of oxygen is by inserting a perforated can of sodium peroxide (*oxone*) into water contained in a suitable metallic generator. Most of the commercial oxygen is now prepared by the fractional distillation of liquid air. Oxygen is a colorless, odorless, and tasteless gas, which is non-inflammable, but one of the best supporters of combustion. Its use in medicine is becoming more extended day by day, it being used to aid respiration in extreme cases where the lungs refuse to absorb ordinary air. For such emergency cases a good quality of oxygen is absolutely necessary, and it behooves the pharmacist to arrange to procure the gas with little loss of time. The manufacture of the gas for such purposes by the pharmacist is rarely practicable, and, moreover, scarcely necessary, inasmuch as the various firms in different portions of the country will furnish an excellent quality of oxygen in compressed (liquid) form at a comparatively low figure. Yet it may here be stated that the writer knows of a pharmacist in a small city some years ago who developed quite a business and materially enhanced his reputation by furnishing chemically pure oxygen in rubber bags for just such emergency cases. The official assay of oxygen is based upon the fact that when 50 mils of the gas is shaken with 10 mils of alkaline solution of pyrogallol at least 47.5 mils are absorbed.

Ozone, O_3, is an allotropic form of oxygen. It is usually prepared by passing air through an "ozonizing tube," in which the oxygen of the air by action of the so-called "silent discharge" of electricity is condensed to ozone. Ozonizing tubes are now sold for the purpose of purifying the air in houses. Whether the ozone really purifies the air is a matter of dispute.

AQUA—Water

Summarized Description.
Colorless, limpid, tasteless liquid. Solids, not more than 3 parts to 10,000. For details see U.S.P., p. 53. For *tests for identity*, for *impurities* (organic matter, lead, copper, iron, chlorides, nitrites, nitrates, ammonium compounds) and for *assay* see U.S.P., p. 52 and also Part V of this book.

AQUA DESTILLATA—Distilled Water

(Aq. Dest.)

Preparation.—Distil 1000 volumes of water, throw away the first 100 volumes of distillate, collect the next 750 volumes and throw away the residue left in the still.

Summarized Description.—Colorless, tasteless limpid liquid; neutral to indicators. For details see U.S.P., p. 57. For *tests for identity*, for *impurities* (sulphates, chlorides, calcium, metals, ammonia, carbon dioxide, organic matter) and for *assay*, see U.S.P., p. 57 and also Part V of this book.

AQUA DESTILLATA STERILISATA—Sterilized Distilled Water

(Aq. Dest. Steril.)

Condensed Recipe.
Place distilled water in a flask of hard glass which has been sterilized as directed in the official monograph on sterilization (p. 124). Plug the flask with sterile cotton, boil the water, cool and cover mouth of flask with paper. For details see U.S.P., p. 58.

Remarks.—Of the three official forms of water—*aqua, aqua destillata* and *aqua destillata sterilizata*—the first is supposed to represent the potable water furnished by the ordinary source of supply, and is, therefore, not so pure as distilled water. The question of the water-supply of cities is one receiving much attention at the present time, but it is beyond the limits of this volume to enter into a complete discussion of the subject. It is assumed that the water supplied by a municipality shall be potable; *i.e.*, not merely containing a minimum of the inorganic salts, but also free from the bacteria which enter it through sewage contamination. The pharmacopœia provides a test for the limit of organic matter in the potassium permanganate test, it directing that 100 mils when mixed with 10 mils of diluted sulphuric acid and brought to the boiling-point should not discharge the color imparted to the solution by the addition of 0.4 mil of decinormal potassium permanganate solution, even after boiling for ten minutes. The addition of the quantity of the permanganate solution suggested will tint the water a decided rose color. If organic matter is present when this solution is boiled, the liquid will lose its rose tint, and at the same time a brown precipitate is formed, this change being due to the fact that the potassium permanganate loses its oxygen and is converted by this reaction into the insoluble manganese dioxide. If the water is free from organic matter, no such chemical change occurs, hence the rose tint will remain. This, however, is not an absolutely fair hygienic test, as the presence of innocent organic substances—say, even sugar—produces a similar discharge of the rose tint. Accordingly, the permanganate is of value chiefly from the negative side, that is, water which does not discharge the permanganate tint can be considered free from organic matter, but, on the other hand, the discharging of the color does not necessarily mean the presence of pernicious organic matter. Therefore in examining water the permanganate test should always be considered in conjunction with three other tests recognized by the pharmacopœia—the phenolsulphonic acid test for nitrates, the sulphanilic acid test for nitrites, and the Nessler test for ammonia. In water analysis the last is the most important chemical test for sewage contamination. In the thorough application of this test the water is distilled from an alkaline solution and then from alkaline permanganate solution, whereby any nitrogenous matter present in the water is converted into ammonia, which is detected by treating the distillate with Nessler's reagent. (See p. 449.) This reagent will produce either a yellow coloration or a brown precipitate, according to the amount of ammonia present, and from the extent of coloration has been evolved a scheme for the quantitative estimation of the albuminoid ammonia present in the water. These chemical tests are of value merely in establishing the fact of sewage contamination, and it may here be said that the simple fact of such contamination would be of little danger were the sewage free from the numerous bacteria which cause disease. Of the bacteria causing mischief in potable water, the most dangerous is that of typhoid, which can be detected only by an expert bacteriologist, and that only indirectly, as the identification of the bacilli is so difficult that the so-called typhoid tests are usually based on the detection of the intestinal bacilli, such as Bacillus coli communis. In closing the subject mention may be made of the fact that the best method of water purification is by filtration through deep layers of sand. (See p. 135.) The pharmacopœia intends that *aqua* should be potable water in its purest obtainable state, and such water, after having been proved potable, is permitted to be used by the pharmacist in most of his manufacturing. A water may be hygienically pure and yet contain salts, the presence of which, while nowise affecting the potability of the water, would seriously interfere with the use of such water in the manufacture of chemicals. For this reason the careful pharmacist usually prefers to use in all prescription work distilled water, the price of which is now so low that its general use is not an extravagance.

Distilled water is made, according to the pharmacopœia, by taking a thousand volumes of water, distilling it from a suitable apparatus, rejecting the first 100 volumes which come over, then collecting the subsequent 750 volumes. It will be seen by this process that the first 100 and the last 250 volumes of water are thrown away, the intermediate portion being the only part considered fit for use. The explanation of this procedure is found in the fact that ordinary water is usually impregnated with gaseous substances, such as carbon dioxide and possibly ammonia, and that these gases will pass over with the first 100 volumes; hence this portion is thrown away. The same water contains also solid matter, various salts, and possibly fixed organic material, and this remains in the still, and the pharmacopœial provision against complete evaporation of the water from the residue is to prevent charring, with the subsequent evolution of empyreumatic matter.

The pharmacopœial tests for distilled water are much more severe than for ordinary water. For instance, while the permanganate test applied to ordinary water is that the tint should not be discharged after boiling 100 mils of water with 0.4 mil of decinormal permanganate solution for ten minutes, distilled water is directed to be mixed with 0.1 mil decinormal potassium permanganate solution (one-quarter the quantity). In the storing of distilled water more care should be taken than is usually observed. Tightly corking bottles of distilled water generally results in the development, in the water, of microscopic plants, consisting of many varieties of cryptogams, including Penicillium glaucum and a number of algæ. Experience has shown that if the water is kept in bottles which are loosely stoppered with a pledget of cotton, such growths are not so frequent. At the prescription counter a capital way of handling the water is to place it in a half-gallon, wide-mouthed bottle on the shelf, six or seven feet above the floor. A syphon consisting of a bent glass tube with flexible rubber tube at the end, the rubber tube terminating with a tapering glass tube and provided with a pinch-cock, is placed in the water, the orifice of the bottle being closed with cotton. When water is desired, all that is necessary is to open the pinch-cock and allow the water to syphon into the bottle or graduate, which can then be held on a level with the eye without the necessity of raising the heavy water receptacle (Fig. 230).

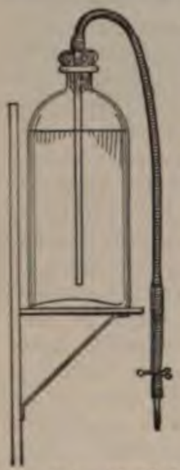


Fig. 230.—Distilled-water holder.

Sterilized distilled water is a new official form of water designed to furnish that fluid chemically and bacterially pure. The pharmacopœial monograph, read in connection with the chapter on sterilization as found in the pharmacopœia and on p. 124 of this book will furnish the information needed by the student.

LIQUOR HYDROGENII DIOXIDI—Solution of Hydrogen Dioxide

(**Liq. Hydrog. Diox.**—Aqua Hydrogenii Dioxidi, U.S.P. VIII. Solution of Hydrogen Peroxide)

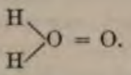
An aqueous solution containing not less than 3 per cent. by weight of H_2O_2 (34.02), corresponding to not less than 10 volumes of available oxygen. Preserve it in a cool place protected from light. Upon removing the stopper from the bottle, not more than a slight pressure should be observed.

Summarized Description.

Colorless, liquid, usually odorless, acid taste, froths when held in mouth, prone to deterioration. Must not contain more than $^4/_{100}$ of 1 per cent. of preservative. For details see U.S.P., p. 246. For *tests for identity*, for *impurities* (non-volatile matter, excess of acid, arsenic, heavy metals, hydrofluoric acid, oxalic acid) and for *assay* see U.S.P., p. 246 and also Part V of this book.

Remarks.—Hydrogen dioxide was discovered by Thenard in the year 1818, and is recognized by the pharmacopœia in the form of a 3 per cent. solution under the name of Liquor Hydrogenii Dioxidi.

The formula H_2O_2 has given rise to considerable discussion as to the structure of this body. At the first glance it seems to lead to the conclusion that either oxygen has the valence I or hydrogen has the valence II. An explanation, however, covering the usual valences of these two elements is that the body consists of two hydroxyl groups, viz., HO—OH. This, however, is combatted by several investigators, who claim that if such a linkage were true, the oxygen would be more tightly combined in this body than it is in water, while the reverse is true. Others claim that the graphic formula of hydrogen dioxide is



that is, it exhibits one atom of tetravalent oxygen, while still others think it represents water with an extra atom of oxygen very loosely attached thereto. In this connection it may be stated that practically all bodies, the formulas of which are not in harmony with the accepted ideas of valence, are usually of unstable character, and no better example of this need be given than the unstable hydrogen dioxide.

The official solution of hydrogen dioxide is prepared by treating barium dioxide with phosphoric acid. The usual method of manufacturing, however, is by substituting for the phosphoric acid the cheaper sulphuric acid. The equation of manufacture from sulphuric acid is as follows:

$$BaO_2 + H_2SO_4 = H_2O_2 + BaSO_4.$$

From this will be seen that the barium dioxide is converted into the insoluble barium sulphate, from which the solution of hydrogen dioxide can be removed by simple filtration.

The pharmacopœia provides an assay of hydrogen dioxide, based on the quantity of potassium permanganate solution required to oxidize the same.

The official solution is a clear, colorless liquid, having a slightly acidulous taste, producing a peculiar sensation and a soapy froth in the mouth. This peculiar sensation is due to its oxidizing action on the mucous membrane and its excretions. Its chemical and medical action is based entirely on the amount of oxygen that it gives up under such conditions, and it may be here said that the solution, giving off its oxygen on standing, deteriorates rapidly. Not only this, but the evolution of oxygen in tightly closed bottles is sometimes so considerable as to cause an explosion. Hence it is advisable to avoid an overtight stopping of the bottle, unless the latter is very stout. Manufacturers preserve hydrogen dioxide solution by the addition of a small amount of acetanilid and the present pharmacopœial test for limit of preservative gives tacit approval of the custom. Hydrogen dioxide is used in medicine as an antiseptic, and in the arts as an oxidizer. An illustration of the latter application is the custom, formerly in vogue, of bleaching dark hair a golden tint by the application of hydrogen dioxide. The disastrous effects of the continued treatment of this kind are now so well known that it is used less than it formerly was for this purpose.

Dose.—4 mils (1 fluidrachm).

THE HALOGENS

By the halogens we mean the four elements, chlorine, bromine, iodine, and fluorine. The word halogen is derived from two Greek words, *als*, which means a salt, and *eidos*, which means a likeness, the phrase being coined to illustrate the similarity of the compounds of these elements to salt, sodium chloride, which is taken as the type of haloid salts.

CHLORINE

Symbol, Cl. Atomic weight, approximately 35.5

This element derives its name from the Greek word *chloros*, which means green, because of the greenish-yellow tint of the gas itself. Chlorine was isolated by Scheele in 1774, who obtained it from hydrochloric acid by treatment similar to that now in vogue in its manufacture. By reason of its origin Scheele called the new substance *dephlogisticated muriatic acid*, because he concluded it represented hydrochloric acid which had been freed from phlogiston, that hypothetic element which played so important a part in the chemical philosophy of the eighteenth century. Scheele considered the substance a compound, and it was not until 1810 that Sir Humphrey Davy proved it was an element, and by him it was named chlorine.

Chlorine is manufactured for pharmaceutic purposes by treatment of hydrochloric acid with manganese dioxide, in which case the reaction is as follows:

$$4HCl + MnO_2 = 2H_2O + MnCl_2 + Cl_2.$$

In practice, for the hydrochloric acid a mixture of common salt and sulphuric acid is usually substituted, the chemical action being by either of the following equations, according to relative proportion of chemicals used:

$$(a)\ 2NaCl + 2H_2SO_4 + MnO_2 = Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2.$$
$$(b)\ 2NaCl + 3H_2SO_4 + MnO_2 = 2NaHSO_4 + MnSO_4 + 2H_2O + Cl_2.$$

This process has the advantage over the first process in avoiding loss of hydrochloric acid, for it will be noticed that when hydrochloric acid is used, half of it goes to make manganese chloride, while in the second process the metals combine with the less expensive sulphuric acid.

An economic modification of the first process is found in *Weldon's regenerative process*, which consists in treating the manganese chloride with lime in the presence of air, the reaction being as follows:

$$MnCl_2 + 2CaO + O = CaCl_2 + CaMnO_3.$$

From the calcium chloride thus produced hydrochloric acid can be obtained, and from this the chlorine can be easily isolated, while from the calcium manganate, manganese dioxide is produced.

Chlorine is used so largely in the arts that the isolation of the element is one of the great industries especially in England. As in the case of such industries, persistent efforts are made to obtain more satisfactory and cheaper processes of manufacture. The Weldon regenerative process, above cited, was an illustration of the ingenuity used in attempting to cheapen the production of this staple; and investigators turned their efforts to the obtaining of chlorine without the use of the comparatively expensive manganese salt. One chemical process of this character, which has the advantage of being practically continuous, is the *Deacon process*. In this process bricks or other porous pieces of earthenware are impregnated with a saturated solution of the sulphates of copper and sodium;

after heating to redness in a furnace the vapors of hydrochloric acid are passed over them. The following reaction ensues:

$$(a)\ CuSO_4 + 2HCl = CuCl_2 + H_2SO_4.$$

The sulphuric acid of the above reaction is condensed, and is thus saved. The bricks, now impregnated with copper chloride, are then heated in a current of air, the reaction being as follows:

$$(b)\ CuCl_2 + O = CuO + Cl_2.$$

The chlorine vapors are then passed into the desired condensing agent, be it water or lime, while copper oxide remains in the brick. The bricks are then heated in a current of hydrochloric acid, the reaction being:

$$(c)\ CuO + 2HCl = CuCl_2 + H_2O,$$

and the water is allowed to escape as steam. It will oe seen that the bricks are impregnated once more with copper chloride, and from that time on they are treated with successive applications of air and hydrochloric acid vapor by the reactions *b* and *c*. Thus a comparatively small quantity of copper salt will be made to convert tons of hydrochloric acid into chlorine.

Of late chlorine has been produced by electrolytic methods, the Castner process consisting of passing electricity through a solution of sodium chloride, the negative pole being in a separate compartment, access to which is through a layer of mercury. In this way the salt is decomposed into chlorine and sodium hydroxide, whereas when the negative pole is in the same compartment as the positive, chlorinated soda is produced.

A method of obtaining chlorine at the prescription counter is by the treatment of potassium chlorate with hydrochloric acid. The reaction might be expressed by the following equation:

$$KClO_3 + 6HCl = KCl + 3H_2O + 3\ Cl_2.$$

It is, however, more complex than is suggested by the above equation for various oxides of chlorine are produced at the same time. This reaction is used for the extemporaneous manufacture of a preparation similar to chlorine water, and it constitutes the N.F. recipe for compound solution of chlorine. For some years it was a popular prescription in several sections of the country, the physician prescribing, instead of chlorine water, a solution of potassium chlorate containing hydrochloric acid. According to the method in which this prescription is compounded two very different results are obtained. If the potassium chlorate is dissolved in water and the hydrochloric acid added to the diluted solution, we obtain merely an acid solution of potassium chlorate. On the other hand, if the powdered potassium chlorate is placed in a bottle, the prescribed quantity of hydrochloric acid added, and the bottle allowed to stand corked a minute or two, the yellow fumes of chlorine are evolved, and on filling the bottle with water a variety of chlorine water is obtained. In receiving such a prescription the careful pharmacist is frequently in a quandary as to which method he shall pursue. In the writer's experience, several physicians objected to the chlorine water. Therefore the only advice that can be given is to call the attention of the prescriber to the two possibilities, and ask which result is desired. It is usual, however, that the method in which the chlorine is easily evolved is the desired method of compounding the prescription.

The Medical Use of Chlorine.—This represents but a small tithe of its commercial value, it being safe to say that tons of chlorine are used for bleaching and manufacturing purposes, where pounds of chlorine are used in the healing art. In medicine the use of chlorine is chiefly as a disinfectant.

Disinfectants are those bodies which destroy offensive organic matter—material which by decomposition breed disease. Most disinfectants are oxidizing agents, but chlorine is particularly interesting because it in itself is not a complete oxidizing agent. To be an oxidizing agent a body should contain oxygen which it can give up. Oxygen, of course, is not found in chlorine, but this energetic element performs the function by borrowing oxygen of its neighbor in this manner:

$$5Cl_2 + 5H_2O = HClO_3 + 9HCl + O_2.$$

In other words, chlorine acts as an oxidizing agent only in the presence of water.

The above statement also explains the bleaching action of chlorine. The use of chlorine as a bleach was discovered by Berthollet in the year 1788, and the process proved so much more satisfactory for the finishing of textile fabrics than sun-bleaching, then in vogue, that its use soon became extended. At first the various cloth factories produced their own chlorine used in bleaching, but since the manufacture of chlorine was a matter so different from that of the manufacture of cloth, it soon fell into the hands of experts. The transportation of the chlorine to the cloth manufacturers soon became a serious matter. In those days the compression of gases had not reached the stage of perfection that now obtains, and at first the only practical method of dispensing was in the form of an aqueous solution, and the transportation of the large quantity of the water necessary to hold the small quantity of chlorine rendered this plan practically prohibitive. The problem of a practical method of transportation of chlorine was found by Tennant, in the year 1799, in his discovery of chlorinated lime, it being found that freshly burnt lime was capable of absorbing as much as 35 to 40 per cent. of its weight of chlorine. From that time on the cloth manufacturers made use of this bleaching powder, and the manufacture of this chemical is now one of the most important industries in England. Chlorine is found in a loosely combined form in *chlorinated lime*, U.S.P., and in *solution of chlorinated soda*, U.S.P.

Liquor chlori compositus (U.S.P. VIII; N.F. IV) is prepared by warming together in a flask hydrochloric acid and potassium chlorate and after the evolution of chlorine is accomplished cold distilled water is added to the mixture. The finished product, which contains about 0.4 of 1 per cent. of chlorine, should be freshly prepared whenever wanted. (See p. 190.)

Aqua chlori (U.S.P. 1890) was a saturated aqueous solution of chlorine gas (0.4 per cent); the gas being produced by the action of manganese dioxide on hydrochloric acid.

CALX CHLORINATA—Chlorinated Lime

(Calx. Chlorin.—"Chloride of Lime")

A product resulting from the action of chlorine upon calcium hydroxide, and containing not less than 30 per cent. of available chlorine [Cl = 35.46]. Preserve it in air-tight containers, in a cool and dry place.

Summarized Description.

White, or gray-white granular powder, smelling of chlorine; deliquesces and decomposes on exposure; partly soluble in water and alcohol, entirely soluble in diluted acetic acid with liberation of chlorine. For details see U.S.P., p. 96. For *tests for identity*, and for *assay*, see U.S.P., p. 96 and also Part V of this book.

Remarks.—Chlorinated lime is defined as a compound resulting from the action of chlorine upon calcium hydroxide, and containing not less than 30 per cent. of available chlorine. The requirement of the pharmacopœia of 1890 (35 per cent. of available chlorine) was unduly high, experience showing that practically no chlorinated lime of strength greater than 30 per cent. can be found in the market; hence at the last revision the requirement was cut to 30 per cent. As mentioned above, chlorinated lime is made by the passage of chlorine gas over slaked lime, the process being carried on, on a large scale, by passing the gas into specially constructed chambers in which the lime is arranged in different layers on special racks.

Chlorinated lime should not be called "chloride of lime," for it is not chloride of lime; that (or, more correctly, calcium chloride) having the formula $CaCl_2$. Some authorities give the formula of chlorinated lime as $CaOCl_2$, which gives the idea of a definite chemical compound, which the body is not. It is a loose indefinite mixture of calcium chloride, $CaCl_2$, and calcium hypochlorite.

What is calcium hypochlorite? The calcium salt of hypochlorous acid, which comes from hypochlorous oxide.

And what is hypochlorous oxide? That oxide of chlorine in which the element shows its lowest valence.

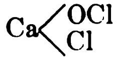
And what is the valence of chlorine?

The valence of chlorine is I, III, V, and VII.

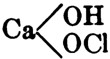
In hypochlorous oxide chlorine has the valence I, hence the formula of the oxide (oxygen having valence II) is Cl–O–Cl or Cl_2O. Hypochlorous acid is made by adding water to the oxide—$Cl_2O + H_2O = H_2Cl_2O_2 = 2HClO$. Calcium has the valence II—one atom replaces two hydrogen atoms of an acid. Since hypochlorous acid, HClO, has but one hydrogen atom and two are needed, we double the formula, making it, as above, $H_2Cl_2O_2$, and replacing the two hydrogen atoms by one calcium atom we get $CaCl_2O_2$, or, as it is usually written, $Ca(OCl_2)$. This is the formula of calcium hypochlorite.

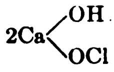
Chlorinated lime is a mixture of calcium chloride ($CaCl_2$) and calcium hypochlorite (CaO_2Cl_2). Let us add these—

Calcium chloride............	$Ca\ \ Cl_2$
Calcium hypochlorite........	$Ca\ O_2Cl_2$

The sum is.... .... $Ca_2O_2Cl_4$, or $2CaOCl_2$, for which the graphic formula  $\mathrm{Ca}\begin{matrix}\diagup \mathrm{OCl}\\ \diagdown \mathrm{Cl}\end{matrix}$ has been assigned.

There are few chemicals regarding whose composition there has been more discussion and less resultant knowledge. Besides the two formulas just given, there have been a number of other suggestions as to its composition.

Thus, in order to explain why a large residue of calcium hydroxide is left when the chemical is extracted with water (for a mixture of calcium chloride and calcium hypochlorite would be completely soluble), it has been claimed that chlorinated lime is a mixture of calcium chloride with a body  $\mathrm{Ca}\begin{matrix}\diagup \mathrm{OH}\\ \diagdown \mathrm{OCl}\end{matrix}$. This body is supposed to dissociate when treated with water as follows:



$$2\mathrm{Ca}\begin{matrix}\diagup \mathrm{OH}\\ \diagdown \mathrm{OCl}\end{matrix} = Ca(OCl)_2 + Ca(OH)_2.$$

Is it not possible that chlorinated lime is a solution or physical combination of chlorine gas in calcium hydroxide plus more or less calcium chloride?

This would explain how calcium hydroxide remains when water is added; this would also explain why chlorinated lime constantly loses chlorine on standing. Chlorinated lime is used as a general disinfectant. Enormous quantities are now employed for the purification of the public water supply.

LIQUOR SODÆ CHLORINATÆ—Solution of Chlorinated Soda

(Liq. Sod. Chlorinat.—Labarraque's Solution)

An aqueous solution of chlorine compounds of sodium, containing not less than 2.5 per cent. of available Cl. Preserve the Solution in well-stoppered bottles, in a cool place, protected from light.

Summarized Description.

Pale green liquid; faint odor of chlorine; alkaline taste. For details see U.S.P., p. 253. For *tests for identity*, and for *assay* see U.S.P., p. 253 and also Part V of this book.

Recipe.

For full details of manufacture, see Part VII.

Assay.—See Part V.

Remarks.—This preparation is made by adding a solution of monohydrated sodium carbonate to a paste obtained by triturating chlorinated lime with water. The resulting mixture is filtered and enough water is used to wash the precipitate to make a product containing 2.5 per cent. of available chlorine. Elvove suggests its preparation by passing chlorine gas through a solution of sodium hydroxide, of the proper strength.

Solution of chlorinated soda is called *Labarraque's solution*, after the French chemist who devised the original formula. *Javelle water*, or solution of chlorinated potassa, was the original preparation, but experience showed Labarraque's solution to be the more satisfactory preparation, hence Javelle water has fallen into disuse. Note that these two preparations are called solutions of *chlorinated* soda and potassa, with the express intention of emphasizing the uncertainty of the chemical character, and it may be here stated that these two preparations, as well as the chlorinated lime above mentioned, are now considered as irregular solutions of chlorine in the alkalies rather than as definite chemicals.

BROMINE

Symbol, Br. Atomic weight, approximately, 80

Bromine (U.S.P. VIII; N.F. IV) was isolated by Balard in 1826 from water of the Mediterranean. On account of the very irritating odor it possesses, the discoverer named it after the Greek word *bromos*, which means a stench. Bromine is made from the bromides by a process analogous to that for the isolation of chlorine—*i.e.*, by treatment of the bromide with sulphuric acid and manganese dioxide—a sufficient quantity of acid is added so that at the end of the reaction the manganese will be of the form of a sulphate, thus insuring complete isolation of the bromine. As the source of bromine a native brine called bittern is generally used. This bittern is found in various sections of the world, one of the chief sources of supply being salt wells, found in the southwest of West Virginia and in the adjacent territory of southeast Ohio and western Pennsylvania. This bittern contains sulphates, bromides, and chlorides of the alkalies, chiefly of magnesium, and a crude concentration of the brine causes the crystallization of the less soluble sulphates and chlorides, leaving a mother liquid consisting chiefly of magnesium bromide. From this mother liquid bromine is obtained by the following reaction:

$$MgBr_2 + MnO_2 + 2H_2SO_4 = MgSO_4 + MnSO_4 + 2H_2O + Br_2.$$

In addition to the explanation of the reaction given above it need only be added that the bromine, on distilling from the reacting mixture, is condensed in earthenware worms, and enters the market after purification by redistillation. Bromine is a very heavy brown liquid, specific gravity 3.000, having a disagreeable and irritating odor. The corrosive action of its vapor renders it necessary to use care in handling, as it is apt to cause injury to the mucous membrane of the nose and throat and also to the delicate tissue of the eye. The liquid, bromine, is decidedly caustic, hence the operator must be careful to avoid dropping same on his hands or face.

It is, of course, largely used in the preparation of the very popular bromides. On treating a solution of soda with bromine we obtain solution of sodium hypobromite, which is analogous to the Labarraque's solution just described, and is used instead of Labarraque's solution in determination of urea. The National Formulary gives a recipe for *liquor bromi.* (See p. 190.)

IODUM—Iodine

It contains not less than 99.5 per cent. of I (126.92). Preserve it in glass-stoppered bottles, in a cool place.

Summarized Description.

Bluish-black rhombic plates, having metallic lustre; distinctive odor; acid taste; sp. gr. 4.66; stains skin brown; soluble in 2950 parts of water, in 12.5 parts of alcohol, in aqueous solution of potassium iodide. For details see U.S.P., p. 228. For *tests for identity*, for *impurities* (moisture, cyanogen, chlorine, bromine, iodine cyanide) and for *assay* see U.S.P., p. 228 and also Part V of this book.

Remarks.—This element was discovered by Courtois in the year 1811, and the discovery was announced by Clement before the National Institute November 29, 1813. It was named by Gay-Lussac (1813) after the Greek word *iodos*, meaning violet, on account of the violet tint of its vapor. Iodine was formerly obtained entirely from the ashes of marine plants. In some sections of the world, notably the North of Ireland and on the Scotch coast, these weeds were collected in considerable quantities, and after being dried, were burned, the ashes being called "*kelp*" in Ireland, and "*varec*" in Normandy. These ashes contain iodides, and by treatment with manganese dioxide and sulphuric acid they yield iodine by either of the following reactions:

$$(a)\ 2KI + MnO_2 + 2H_2SO_4 = K_2SO_4 + MnSO_4 + 2H_2O + I_2.$$
$$(b)\ 2KI + MnO_2 + 3H_2SO_4 = 2KHSO_4 + MnSO_4 + 2H_2O + I_2$$

In both these cases the iodine is separated by sublimation.

In other sections other methods of isolation are employed, such as treatment of the ashes with chlorine, nitrous acid, ferrous and copper sulphates. Moreover, processes are now in vogue in which an infusion of the sea-weed is used instead of the ashes, these later and more economic processes being devised in order that the European product might compete with the great modern source of iodine, the nitre beds of Peru.

The Peruvian nitre consists chiefly of sodium nitrate (the so-called Chile saltpeter). This is obtained from the ore by lixiviation, and the saline solution is concentrated to the point at which the sodium nitrate will crystallize.

The mother liquor from this crystallization contains sodium iodate, which is obtained by evaporating the liquid to dryness. Iodine is isolated from this impure iodate, $NaIO_3$, by treatment with sulphurous acid, the reaction being:

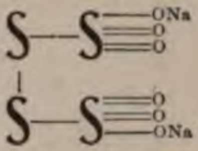
$$3H_2SO_3 + HIO_3 = 3H_2SO_4 + HI.$$
$$5HI + HIO_3 = 3H_2O + 3I_2.$$

In all these South American processes except the last the crude iodine is separated from the other products by filtration. It is then purified by sublimation. Iodine is a blue-black, metallic-appearing solid, insoluble in water, but soluble in a solution of potassium iodide, in alcohol, in ether and chloroform, the solution in the last two solvents being a pink to purple tint. It is quite volatile, hence it must be preserved in well-closed bottles, and by reason of its volatility it is usually purified by sublimation, hence the trade name of the best quality of iodine is *resublimed iodine.*

The test for iodine is the fact that it turns mucilage of starch an intense blue-black color. When this test is applied for the detection of iodides it is necessary to liberate the iodine by treatment with some substance containing free chlorine. The iodides form a characteristic yellow precipitate of silver iodide when treated with a solution of silver nitrate, and this precipitate, unlike similar precipitates from chlorides and bromides, does not dissolve in ammonia water. This is the basis of the official test for distinction of bromides and chlorides given in the pharmacopœia. The aqueous and alcoholic solutions of free iodine have a brown tint, and such solutions are decolorized by treatment with sodium thiosulphate (hyposulphite, see p. 444), the equation being:—

$$I_2 + 2Na_2S_2O_3 = 2NaI + Na_2S_4O_6.$$

Both products of the reaction just given—sodium iodide and sodium tetrathionate—are colorless, and the latter chemical has the graphic formula—



The word "tetrathionate" means literally "four-sulph-ate," *tetra* being Greek for "four," and *thion* means "sulphur" in the same language.

This decoloration of iodine by sodium hyposulphite is applied in making the so-called *decolorized tincture of iodine* of the National Formulary (p. 236). As will be seen from above equation, the name is a misnomer, as the decolorized preparation contains no uncombined iodine, and for all purposes a solution of potassium or of sodium iodide would have equal therapeutic value.

The property of sodium hyposulphite of decolorizing iodine is applied for the quantitative estimation of that element and its derivatives. For this purpose a volumetric solution of sodium hyposulphite is dropped into the iodine solution until the latter is decolorized.

In order sharply to distinguish the end reaction, a starch paste is used as an indicator, the blue-black tint in the mixture being discharged the moment a sufficient quantity of the volumetric solution is added. (See Chapter LIV.)

Dose.—5 milligrammes (1/12 grain).

TINCTURA IODI—Tincture of Iodine

(Tr. Iodi)

An alcoholic solution of iodine and potassium iodide. *One hundred mils* contains not less than 6.5 Gm. nor more than 7.5 Gm. of I (126.92) and not less than 4.5 Gm. nor more than 5.5 Gm. of KI (166.02).

Condensed Recipe.

Dissolve 70 Gm. iodine in a concentrated aqueous solution of 50 Gm. potassium iodide. Then add enough alcohol to make 1 liter. For details see U.S.P., p. 457.

Assay.—See U.S.P., p. 458 and Part V of this book.

Remarks.—Tincture of iodine is an alcoholic solution containing 7 per cent. of iodine, 5 per cent. of potassium iodide and 5 per cent. of added water. The addition of the iodide was suggested by La Wall, as a means of preventing loss of iodine strength of the tincture, as iodine in simple alcoholic solution is partly converted into hydriodic acid and such a tincture on assay will show a deficiency of free iodine. The La Wall plan is a success, as a tincture so prepared, on standing, becomes actually stronger in iodine, due to evaporation of the alcohol.

The other official preparations of iodine are: *compound solution of iodine,* which contains 5 per cent. of iodine dissolved in water by aid of 10 per cent. of potassium iodide (p. 187); and the *ointment of iodine,* which contains 4 per cent. of iodine and 4 per cent. potassium iodide, rubbed with glycerin and benzoinated lard (p. 334).

SULPHUR

Symbol, S. Atomic weight, approximately 32

This element has been known from ancient times, the name being of Latin origin, derived from two words, *sal* (salt) and *pyr* (fire). Sulphur is found in the free state in the neighborhood of volcanoes, it being emitted through these from the interior of the earth. It is also found very widely distributed in combination, for example, *gypsum,* which is calcium sulphate, *iron pyrites* (ferrous sulphide), and *galena* (lead and silver sulphide). The commercial source of sulphur is chiefly crude brimstone, which is obtained either from the sides of volcanoes or else mined in certain sections of the world, as, for example, a very extensive deposit of sulphur in Louisiana.

Sulphur is extracted from the Louisiana mines by sinking several 4-inch steel tubes into the deposit, and passing superheated water through one of the tubes. The heat of the water melts the sulphur, while the pressure forces the fused sulphur through the other tubes into vats or ponds, where it solidifies.

The crude volcanic sulphur is roughly purified by straining and pouring into iron molds. Such sulphur comes into the market in cylindric pieces, one or two feet long and two or three inches in diameter, under the name of *roll sulphur* or *brimstone.* A purer commercial form is *sublimed sulphur* or *flowers of sulphur,* which is made by putting brimstone in cast-iron retorts and collecting the vapors in large, well-cooled chambers, on the floors of which sulphur falls in the form of fine powder.

this procedure is found in the fact that ordinary water is usually impregnated with gaseous substances, such as carbon dioxide and possibly ammonia, and that these gases will pass over with the first 100 volumes; hence this portion is thrown away. The same water contains also solid matter, various salts, and possibly fixed organic material, and this remains in the still, and the pharmacopœial provision against complete evaporation of the water from the residue is to prevent charring, with the subsequent evolution of empyreumatic matter.

The pharmacopœial tests for distilled water are much more severe than for ordinary water. For instance, while the permanganate test applied to ordinary water is that the tint should not be discharged after boiling 100 mils of water with 0.4 mil of decinormal permanganate solution for ten minutes, distilled water is directed to be mixed with 0.1 mil decinormal potassium permanganate solution (one-quarter the quantity). In the storing of distilled water more care should be taken than is usually observed. Tightly corking bottles of distilled water generally results in the development, in the water, of microscopic plants, consisting of many varieties of cryptogams, including Penicillium glaucum and a number of algæ. Experience has shown that if the water is kept in bottles which are loosely stoppered with a pledget of cotton, such growths are not so frequent. At the prescription counter a capital way of handling the water is to place it in a half-gallon, wide-mouthed bottle on the shelf, six or seven feet above the floor. A syphon consisting of a bent glass tube with flexible rubber tube at the end, the rubber tube terminating with a tapering glass tube and provided with a pinch-cock, is placed in the water, the orifice of the bottle being closed with cotton. When water is desired, all that is necessary is to open the pinch-cock and allow the water to syphon into the bottle or graduate, which can then be held on a level with the eye without the necessity of raising the heavy water receptacle (Fig. 230).

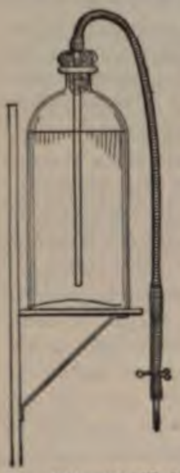


Fig. 230.—Distilled-water holder.

Sterilized distilled water is a new official form of water designed to furnish that fluid chemically and bacterially pure. The pharmacopœial monograph, read in connection with the chapter on sterilization as found in the pharmacopœia and on p. 124 of this book will furnish the information needed by the student.

LIQUOR HYDROGENII DIOXIDI—Solution of Hydrogen Dioxide

(**Liq. Hydrog. Diox.**—Aqua Hydrogenii Dioxidi, U.S.P. VIII. Solution of Hydrogen Peroxide)

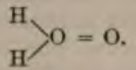
An aqueous solution containing not less than 3 per cent. by weight of H_2O_2 (34.02), corresponding to not less than 10 volumes of available oxygen. Preserve it in a cool place protected from light. Upon removing the stopper from the bottle, not more than a slight pressure should be observed.

Summarized Description.

Colorless, liquid, usually odorless, acid taste, froths when held in mouth, prone to deterioration. Must not contain more than $^4/_{100}$ of 1 per cent. of preservative. For details see U.S.P., p. 246. For *tests for identity*, for *impurities* (non-volatile matter, excess of acid, arsenic, heavy metals, hydrofluoric acid, oxalic acid) and for *assay* see U.S.P., p. 246 and also Part V of this book.

Remarks.—Hydrogen dioxide was discovered by Thenard in the year 1818, and is recognized by the pharmacopœia in the form of a 3 per cent. solution under the name of Liquor Hydrogenii Dioxidi.

The formula H_2O_2 has given rise to considerable discussion as to the structure of this body. At the first glance it seems to lead to the conclusion that either oxygen has the valence I or hydrogen has the valence II. An explanation, however, covering the usual valences of these two elements is that the body consists of two hydroxyl groups, viz., HO—OH. This, however, is combatted by several investigators, who claim that if such a linkage were true, the oxygen would be more tightly combined in this body than it is in water, while the reverse is true. Others claim that the graphic formula of hydrogen dioxide is



$$\begin{array}{l}\mathrm{H}\diagdown\\ \qquad \mathrm{O} = \mathrm{O}.\\ \mathrm{H}\diagup\end{array}$$

that is, it exhibits one atom of tetravalent oxygen, while still others think it represents water with an extra atom of oxygen very loosely attached thereto. In this connection it may be stated that practically all bodies, the formulas of which are not in harmony with the accepted ideas of valence, are usually of unstable character, and no better example of this need be given than the unstable hydrogen dioxide.

The official solution of hydrogen dioxide is prepared by treating barium dioxide with phosphoric acid. The usual method of manufacturing, however, is by substituting for the phosphoric acid the cheaper sulphuric acid. The equation of manufacture from sulphuric acid is as follows:

$$BaO_2 + H_2SO_4 = H_2O_2 + BaSO_4.$$

From this will be seen that the barium dioxide is converted into the insoluble barium sulphate, from which the solution of hydrogen dioxide can be removed by simple filtration.

The pharmacopœia provides an assay of hydrogen dioxide, based on the quantity of potassium permanganate solution required to oxidize the same.

The official solution is a clear, colorless liquid, having a slightly acidulous taste, producing a peculiar sensation and a soapy froth in the mouth. This peculiar sensation is due to its oxidizing action on the mucous membrane and its excretions. Its chemical and medical action is based entirely on the amount of oxygen that it gives up under such conditions, and it may be here said that the solution, giving off its oxygen on standing, deteriorates rapidly. Not only this, but the evolution of oxygen in tightly closed bottles is sometimes so considerable as to cause an explosion. Hence it is advisable to avoid an overtight stopping of the bottle, unless the latter is very stout. Manufacturers preserve hydrogen dioxide solution by the addition of a small amount of acetanilid and the present pharmacopœial test for limit of preservative gives tacit approval of the custom. Hydrogen dioxide is used in medicine as an antiseptic, and in the arts as an oxidizer. An illustration of the latter application is the custom, formerly in vogue, of bleaching dark hair a golden tint by the application of hydrogen dioxide. The disastrous effects of the continued treatment of this kind are now so well known that it is used less than it formerly was for this purpose.

Dose.—4 mils (1 fluidrachm).

THE HALOGENS

By the halogens we mean the four elements, chlorine, bromine, iodine, and fluorine. The word halogen is derived from two Greek words, *als*, In this it will be noticed that we have two atoms of bivalent sulphur; one bond of each is used in holding together its neighboring sulphur atom. Thus, each atom of sulphur has only one bond to which iodine is linked.

Carbonei Disulphidum (U.S.P. VIII) is made by passing the vapors of sulphur through carbon contained in a red-hot tube or cylinder.

Carbon disulphide is a heavy, mobile, inflammable liquid, with the offensive odor of rotten eggs. It is said to be odorless when absolutely pure, a happy condition never as yet attained by the writer, although he has often rectified the disulphide for analytic work.

This rectification can be performed by the ordinary process of distillation, with the one safeguard of preventing direct contact of the distilling flask with flame. For this reason it is even unadvisable to use a flame for heating the water on which the distilling flask rests. If a steam-bath is not at hand, the distillation must be carried on by pouring heated water into the bath, rather than by directly heating the water. As carbon disulphide boils at 47°C., the occasional filling of the water-baths with boiling water will very rapidly volatilize all the carbon disulphide. The chief use of carbon disulphide is as a solvent for India-rubber and was formerly official because of its use for this purpose in preparing mustard paper of the last pharmacopœia.

NITROGEN

Symbol, N. Atomic weight, approximately 14

Nitrogen was discovered as a constituent of the air by Rutherford in 1772. The name nitrogen was coined by Chaptal in 1796 from the two words *nitron*, nitre, and *gennao*, I produce; investigation having shown that it was a constituent of nitre or saltpeter.

Nitrogen is usually prepared on the small scale by heating ammonium nitrite, (or, in practice a mixture of sodium nitrite and ammonium chloride) the equation of reaction being:

$$NH_4NO_2 + \text{heat} = N_2 + 2H_2O.$$

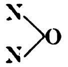
It is now being prepared from the atmosphere by electrolytic processes.

Nitrogen is a colorless, tasteless, odorless, and inert gas, which is of no pharmaceutic value. Its chief occurrence in uncombined state is in the atmosphere, of which it constitutes about 77 per cent. by weight and 79 per cent. by volume, and in which it does the inestimable service of diluting the very active constituent, oxygen. It has been proved that air is a mechanical mixture of nitrogen and oxygen, along with a small quantity of carbonic oxide, moisture, and traces of salts.

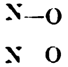
Nitrogen forms five chemical combinations with oxygen, and of these five oxides, only two follow the simple rules of valence.

The graphic formulas of the five are supposed to be as follows:

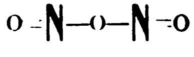
Nitrogen monoxide, N_2O (Laughing-gas),



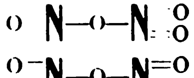
Nitrogen dioxide, N_2O_2,



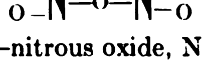
Nitrogen trioxide, Nitrous oxide, N_2O_3,



Nitrogen tetroxide, N_2O_4,



Nitrogen pentoxide, Nitric oxide, N_2O_5,



Of these five oxides, two—nitrous oxide, N_2O_3, and nitric oxide, N_2O_5—will be considered in the next chapter among the acids. Of the other three, one is now official.

Nitrogen dioxide, N_2O_2, is incorrectly called nitric oxide, as that name more properly belongs to nitrogen pentoxide, N_2O_5, since that is the oxide from which nitric acid is derived.

Nitrogen dioxide is the colorless gas produced in a nitrometer when ethyl nitrite or other nitrites are treated with potassium iodide and sulphuric acid. (See assay of spirit of nitrous ether, p. 596). It can be studied only in an inclosed apparatus like a nitrometer, for as soon as it comes in contact with the atmosphere it is converted into nitrogen tetroxide.

For this reason, while it is produced in oxidations with nitric acid (see Manufacture of Solution of Ferric Sulphate, Part VII), it can never be detected when such reactions occur in the air, where, instead of the colorless nitrogen dioxide, the red-brown fumes of nitrogen tetroxide are evolved.

NITROGENII MONOXIDUM—Nitrogen Monoxide

(Nitrogen. Monox.—Nitrous Oxide)

Nitrogen Monoxide gas [$N_2O = 44.02$].

Summarized Description.

Colorless gas; slight odor; sweetish taste; usually dispensed compressed in metallic cylinders; soluble in 0.76 volume of water at 25°C. For details see U.S.P., p. 280.

For *tests for identity* and for *impurities* (carbon dioxide, halogens, acids or bases, reducing substances) see U.S.P., p. 280 and also Part V of this book.

Remarks.—This new official substance is called *laughing gas* and also, unfortunately, nitrous oxide, a synonym which should fall into disuse, since the term more properly belongs to nitrogen trioxide. It is made by heating ammonium nitrate, viz.:

$$NH_4NO_3 + \text{heat} = N_2O + 2H_2O$$

It is a colorless gas of faint odor and sweetish taste and is used as an anesthetic, not only in dental practice but also in such operations as removing adenoid growths. It has lately been brought into prominence as an anesthetic by Crile who uses it in conjunction with the hypodermic administration of morphine and scopolamine and with a local anesthetic like novocaine in performing "shockless operations."

Nitrogen tetroxide, N_2O_4, is of interest to us only because a product of oxidation with nitric acid mentioned above.

It is a heavy, red-brown, irritating vapor, and can be easily produced by pouring nitric acid on copper turnings.

It is claimed by some writers that N_2O_4 is colorless, and that the red-brown gas has the formula NO_2.

PHOSPHORUS—Phosphorus

(Phosphor.)

Phosphorus [$P = 31.04$] must be carefully preserved under water, in strong, well-closed containers, in a secure and moderately cool place, protected from light.

Summarized Description.

Translucent, almost colorless solid, turning on exposure white, red or even black, upon the surface; waxy consistence, ignites on exposure to air; sp. gr., 1.83; melts at 44°C.; soluble in about 330 parts of absolute alcohol and about 25 parts of chloroform; practically insoluble in water. For details see U.S.P., p. 319.

For *tests for identity* and for *impurities* (arsenic, sulphur) see U.S.P., p. 319 and also Part V of this book.

Remarks.—The name of this element is derived from the two Greek words, *phos*, "light," and *pherein*, "to bring," hence the name light-carrier, designating the prominent characteristic of phosphorus, the term having been used before the discovery of phosphorus for other phosphorescent bodies.

Phosphorus was discovered by Brandt in 1669. This alchemist, in examining urine, placed some in a retort and subjected it to distillation. The residue in the retort, after the distillation, became charred, and the charcoal acted on the phosphates present, isolating free phosphorus, which appeared in the retort with its characteristic phosphorescence.

The manufacture of phosphorus from urine was in vogue for one hundred years, it being first prepared from bones by Scheele, in 1771, the element being discovered in bones by Gahn a few years earlier.

Phosphorus is never found in the free state in nature, as contact with the air causes a combination of it with the atmospheric oxygen.

It is found abundantly in the form of calcium phosphate in many minerals, such as *apatite*—calcium chlorophosphate and the "phosphate rock" of the southern Atlantic States. Calcium phosphate is also the main inorganic constituent of the bones, bone-ash containing 86 per cent. of that chemical.

Phosphorus is made from bone-ash, there being several stages in the process. The bone-ash is first treated with sulphuric acid, thus forming calcium sulphate and acid calcium phosphate, as shown in the following equation:

$$(a)\ Ca_3(PO_4)_2 + 2H_2SO_4 = 2CaSO_4 + CaH_4(PO_4)_2.$$

In passing, it might be mentioned that the acid calcium phosphate just cited is the constituent of the popular "*acid phosphates*," and similar preparations, such as the solution of phosphoric acid of the former editions of the National Formulary. In making phosphorus the acid phosphate obtained in the above reaction is then submitted to a high heat, whereby it loses water and is converted into calcium metaphosphate, as shown in the following equation:

$$(b)\ CaH_4(PO_4)_2 + \text{heat} = Ca(PO_3)_2 + 2H_2O.$$

This calcium metaphosphate is then heated with charcoal in a retort, and is decomposed into phosphorus and calcium pyrophosphate, as shown in the following equation:

$$(c)\ 2Ca(PO_3)_2 + 5C = P_2 + Ca_2P_2O_7 + 5CO.$$

A better yield of phosphorus can be obtained by using the larger proportion of carbon suggested in the following equation, thus getting calcium phosphate instead of calcium pyrophosphate:

$$(d)\ 3Ca(PO_3)_2 + 10C = P_4 + Ca_3(PO_4)_2 + 10CO.$$

In practice the reactions *b* and *c* are conducted together, and the isolated phosphorus is separated from the calcium pyrophosphate (or phosphate) by distillation; the distilled phosphorus being collected under warm water and run into molds while still fused.

Phosphorus is now being manufactured by heating calcium phosphate with charcoal and sand in the electric furnace, under an atmosphere of coal-gas (Parker process).

Phosphorus is interesting as assuming the characteristic allotropic forms—the yellow, the red, and the metallic. *Phosphorus* (U.S.P.) is the yellow variety, and usually comes in commerce in cylindric sticks which must be kept under water or otherwise protected from the action of the atmosphere. This yellow phosphorus is as soft as wax, melts at 44°C., is soluble in absolute alcohol, ether, chloroform, and fixed oils. Exposed to the air, yellow phosphorus catches fire spontaneously, emitting dense white fumes of phosphoric oxide, P_2O_5. This property renders it necessary to handle phosphorus with the utmost care, and in weighing same for pharmaceutic purposes it should always be done in water; *i.e.*, the stick of phosphorus should be cut under water contained in an evaporating dish, and weighed, not directly on the scale-pan, but in a beaker glass containing water. That the weight of the beaker glass and the water should be previously determined goes without saying.

As mentioned above, the yellow phosphorus, even under water, emits a faint, whitish light, which is supposed to be due to an evolution of minute quantities of phosphine, PH_3, and the immediate decomposition of same with the evolution of a microscopic flame.

The red phosphorus is prepared by heating the yellow variety to 300°C. in closed tubes, in an atmosphere of nitrogen. This product is a dark-red powder, perfectly stable in air, and comparatively non-toxic. Red phosphorus is largely used in place of yellow phosphorus in the manufacture of matches and the like, and its use has greatly lessened the dangers of this trade.

Metallic phosphorus is made by heating the red to 530°C. *in vacuo*. It appears in steel-like scales, and has no interest in pharmacy.

Medical Properties.—Powerful nervous stimulant; a violent poison.

Dose.—0.5 milligramme ($\frac{1}{120}$ grain).

Antidote.—Old (ozonized) oil of turpentine.

Official Preparation.—Pills of phosphorus, each containing about $\frac{1}{100}$ grain of phosphorus (p. 312).

The National Formulary gives recipes for *oleum phosphoratum* or phosphorated oil, a 1 per cent. solution of phosphorus in expressed oil of almond; *liquor phosphori* or Thompson's solution of phosphorus, containing $\frac{1}{100}$ of 1 per cent. of phosphorus in a mixture of glycerin and dehydrated alcohol, spirit of peppermint being used as a flavor; and *elixir of phosphorus*. (See p. 209.)

CARBON

Symbol, C. Atomic weight, approximately 12

The name of this element is derived from the word *carbo*, which was the Latin name for coal.

Carbon is found in the free form as diamond, graphite, and coal, while its combinations are very widely distributed. For example, all organic matter contains carbon. It is also found as carbonate in several well-known minerals; thus, marble and lime-stone are calcium carbonate. while dolomite is a mixture of calcium and magnesium carbonates.

Carbon, as such, is found in three allotropic forms, they being diamond, graphite, and coal. *Diamond* is the crystalline form of carbon, and is found in hard, transparent masses, possessing the specific gravity 3.5 to 3.6. The proof of its being carbon pure and simple is that when ignited in a stream of oxygen it is all consumed with the exception of a trace of ash (about $\frac{1}{10}$ of 1 per cent.), forming nothing but carbon dioxide gas. Its formation from the other varieties of carbon has already been explained on p. 149.

Graphite is a gray-black, soft, amorphous solid, known to all as the so-called "lead" of the pencil. It has a specific gravity of about 2.25, and is of interest because of its resistance to heat. For this reason graphite is used for making crucibles—the so-called black-lead crucibles. (See p. 82.)

Coal is the impure, non-crystalline form of carbon, and can be divided into two commercial varieties, *anthracite*, or hard coal, *bituminous*, or soft coal. Coal, on being heated in retorts, gives up its volatile portion, yielding illuminating gas, ammonia, and coal-tar, while the residue is the commercial *coke*, which contains about 91 per cent. carbon. The great value of coal and coke as a fuel has already been touched upon on p. 67.

Charcoals are more or less pure forms of amorphous carbon.

CARBO LIGNI—Wood Charcoal

(Carbo Lig.—Charcoal)

Charcoal prepared from soft wood, and very finely powdered. Preserve it in well-closed vessels.

Summarized Description.

Black, odorless, tasteless powder, free from grit; burns with non-luminous flame, leaving not more than 7.5 per cent. of ash; should give only a faint brown color, when it is boiled in solution of potassium hydroxide. For details see U.S.P., p. 101.

Remarks.—This is to be prepared from soft wood, and is to be very finely powdered; that prepared from willow-wood being considered best.

The pharmacopœia directs that the wood-charcoal be kept in well-closed vessels, because it readily absorbs odors. In fact, the medical value of wood-charcoal depends very largely on this property of absorbing gases, and it is for this reason that charcoal is valuable in indigestion. The process of manufacture is given on p. 83.

Dose.—1 Gm. (15 grains).

Carbo Animalis (U.S.P. VIII), commercially called *bone-black*, is prepared by placing dried bones in a cast-iron retort and carbonizing (during the process a liquid distils over which is called *bone oil*), and the residue in the retort is then removed and reduced to powder. Animal charcoal contains the carbon from the organic matter of the bones plus all the bone-ash, and it therefore contains a large amount of calcium phosphate. Animal charcoal is used as a decolorizer, as explained on p. 140, and the presence of calcium phosphate therein renders its use inadvisable in removing color from liquids containing acids as calcium phosphate will dissolve therein. Preferable therefore is:

Carbo Animalis Purificatus (U.S.P. VIII) which is made by digesting animal charcoal with hydrochloric acid on a sand-bath for a period of eight hours, and, after straining the liquid, returning the charcoal to the vessel. The operation is repeated with a second amount of hydrochloric acid, and the digestion continued for two hours. Finally, the acid is drained off, the charcoal freed from all traces of acid by washing with water, and the product dried. The acid effects the solution of the bone-ash by converting it into soluble acid calcium phosphate, described in the manufacture of phosphorus (p. 384). Purified animal charcoal is an excellent decolorizer, and should always be used by the pharmacist in preference to the crude product. Knecht claims that animal charcoal contains nitrogen and that its decolorizing power is directly proportional to its nitrogen content.

The removing of color by means of purified animal charcoal is done by macerating the liquid with the charcoal for several hours, and finally filtering. It is well to remember that animal charcoal not only absorbs the color from a solution, but also absorbs some active plant principles, such as alkaloids and glucosides. Therefore, care should be taken to avoid the loss of active ingredients by too long contact with the charcoal.

Lamp-black is carbon produced by burning rosin, petroleum, or natural gas in a limited amount of air, and collecting the "soot" thus produced.

BORON

Symbol, B. Atomic weight, approximately 11

The word boron comes from *boraq*, which was the Arabic name for borax. The element was first isolated by Gay-Lussac and Thenard in 1808.

Boron occurs in nature in the form of boric acid, sodium borate, and boracite, the latter being a magnesium borate. It is found in two allotropic forms, crystalline and amorphous. It is now said that the crystalline variety is a mixture of carbon, aluminium and boron. Its compounds with hydrogen and oxygen yield several acids, such as boric, metaboric, and pyroboric acids. Boron is not official, but it is found in official bodies—boric acid and borax.

ACIDUM BORICUM—Boric Acid

(Acid. Bor.—Boracic Acid)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99.5 per cent. of H_3BO_3 (62.02).

Summarized Description.

Colorless scales, triclinic crystals or white bulky powder; unctuous to touch; odorless; faintly bitter; soluble in 18 parts of water and 15.3 parts of alcohol. Heated it first forms metaboric acid and then fused to tetraboric acid and finally to boron trioxide. For details see U.S.P., p. 9.

For *tests for identity*, for *impurities* (heavy metals, arsenic) and for *assay* see U.S.P., p. 9 and also Part V of this book.

Remarks.—The formula of this compound, commonly called *boracic acid*, has already been discussed (p. 358), so here it is only necessary to emphasize the fact that boric acid is the only true official ortho-acid.

Boric acid is found in the free form in lagoons in volcanic regions of Tuscany, the water being evaporated with the aid of the jets of steam emitted from the volcanic soil.

It is now made in large quantities in this country from native borax (p. 430), by treating it with hydrochloric acid, the equation being:

$$Na_2B_4O_7 10H_2O + 2HCl = 2NaCl + 4H_3BO_3 + 5H_2O.$$

Boric acid is found in the form of crystalline micaceous scales, which possess a peculiar unctuous feeling. Boric acid is volatile, but more freely, however, in the vapor of water than if heated by itself. Boric acid is now popular in the form of an impalpable powder, and the preparation of this caused considerable annoyance on account of the slipperiness of the crystals, until it was found that trituration of boric acid in a warmed mortar or mill brings the desired results.

The two tests of boric acid are, first, the fact that an alcoholic solution burns with a flame enveloped with a green mantle, and, secondly, its property of changing yellow tumeric paper to a reddish brown.

Boric acid is a valuable antiseptic and is largely used in domestic practice for this purpose. It is a constituent of *glycerite of boroglycerin* and of *ointment of boric acid*, as well as in the antiseptic solution and alkaline antiseptic solution of the National Formulary.

Dose.—500 milligrammes (8 grains).

SILICON

Symbol, Si. Atomic weight, approximately 28

The word silicon is derived from *silica*, or sand, which in turn is derived from the Latin *silex*, which means flint. The element was isolated by Berzelius in 1823. Silicon is the most abundant element on the earth's surface.

Thus, quartz, sand, opal, agate, and infusorial earth are more or less pure silicic oxide.

Silicon is another element appearing in two allotropic forms, crystalline and amorphous. None of the forms of silicon is of sufficient pharmaceutic interest to merit more than passing notice. Silicon, as shown on p. 354, yields one oxide, SiO_2; one form of which, purified siliceous earth, is official. The hypothetic combinations of this, with water, are silicic acids, H_2SiO_3 and H_4SiO_4, and the salts of these acids are the ordinary silicates. Silicates of complex formulas, such as *orthoclas*, $K_2AlSi_6O_{16}$, are known.

Glass is a combination of the silicates of sodium or potassium with lead or calcium.

The test for soluble silicates is that they yield with acids a white gelatinous precipitate of orthosilicic acid, H_4SiO_4.

The silicates other than those of the alkalies are insoluble in all acids, even the strongest, except hydrofluoric acid.

In order to obtain these silicates in soluble form it is necessary to fuse them with a mixture of sodium and potassium carbonates, whereby silicates of sodium and potassium are formed.

TERRA SILICEA PURIFICATA—Purified Siliceous Earth

(Ter. Sil. Purif.—Purified Kieselguhr—Purified Infusorial Earth)

A form of silica (SiO_2 = 60.30) consisting of the frustules and fragments of diatoms, purified by boiling with diluted hydrochloric acid, washing and calcining. It does not contain more than 10 per cent. of moisture. Preserve it in tightly closed containers.

Summarized Description.

Very bulky fine powder; white, light gray or pale buff; absorbs 4 times its weight of water; insoluble in water. For details see U.S.P., p. 439.

For *tests for identity*, and for *impurities* (moisture), see U.S.P.

Remarks.—This new official substance represents that form of infusorial earth known as *Kieselguhr*. It is now used as a filtering agent and is recommended for this purpose in the pharmacopœial monograph on aromatic waters. Kaolin, aluminum silicate, is discussed on p. 494 and sodium silicate on p. 442.

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CHAPTER XXIV

THE ACIDS

An acid is a substance which changes blue litmus-paper red, and combines with bases to form salts. The substances answering this definition are both inorganic and organic, and among the inorganic acids, as already mentioned, are found both binary and ternary compounds. The binary compounds are the four bodies, hydrochloric acid, HCl, hydrobromic acid, HBr, hydriodic acid, HI, and hydrofluoric acid, HFl. These four are called *haloid acids*, because derived from the four halogen elements. Three of these haloid acids are recognized by the pharmacopœia either alone or in pharmaceutic preparations.

Organic acids consist of carbon radicals combined with the group *carboxyl*, COOH. These will be discussed under their proper grouping in Part IV.

The inorganic acids are, with the exception of the haloid acids just mentioned, hydroxides of the negative elements. Acids may be solids, liquids, or gases; in fact, all the members of this large group have little in common save their acid action on litmus-paper and their ability to form salts with the alkalies.

In this chapter we will discuss all the official inorganic acids except boric acid, chromic acid, and arsenous acid, the three being considered under the elements from which derived. All those considered in this chapter are liquids, and are commercially called the *heavy acids*, because their specific gravity is greater than water. These acids are usually in the concentrated form, and decidedly caustic. Hence in handling them great care must be taken to avoid bringing them in contact with delicate substances. If, in handling, they are spattered on the skin, they should be immediately washed off; if the area of burn is considerable, it should be covered with emollients of mildly alkaline character, such as lime liniment or sodium bicarbonate. Their active character prevents their ordinary storage in wood or metal, although it might be of interest to mention that sulphuric acid in concentrated form can be safely stored in iron tanks, that acid attacking iron only when diluted. In pharmacy, however, such acids must be handled entirely in glass or porcelain, and in purchasing quantities of the same they are usually furnished in large glass containers boxed with straw, called *carboys*. In handling these carboys it is usually advisable to have trunnions on which they can be rocked (Fig. 231), though, with careful handling, this expense may be avoided.

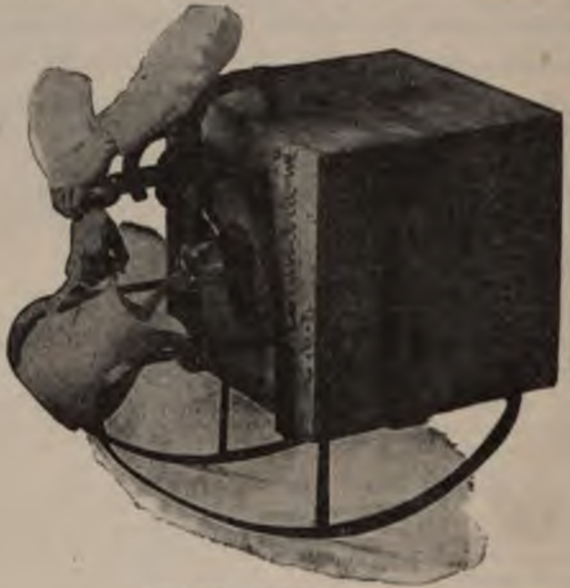


Fig. 231.—Carboy trunnion

There is no uniformity in the commercial strength of the different strong acids, the usual custom being to furnish an acid of the greatest concentration feasible.

It is useful to memorize the following strengths and specific gravities:

	HCl	H_2SO_4	HNO_3
Percentage of absolute acid	31 to 33	93 to 95	67 to 69
Specific gravity (approximate)	1.16	1.83	1.40

While the pharmacopœial concentrated acids vary in strength, the same standard demands that diluted acids contain 10 per cent. of absolute acid, except diluted acetic acid (6 per cent.) and diluted hydrocyanic acid (2 per cent.). A very convenient method of estimating the strength of acids is by their specific gravity. As an illustration, it will be noted above that the specific gravity of sulphuric acid is 1.83. Water, which is the only likely adulterant, has, of course, the specific gravity of 1.00, and if sulphuric acid is diluted with water, the specific gravity will fall to a point somewhere between 1.83 and 1.00. The only official liquid acid whose specific gravity is not a criterion of strength is acetic acid. (See p. 603.) The antidote for acids is mild alkali, such as calcined magnesia or lime liniment, this being a good illustration of a chemical antidote acting on an acid to form a neutral and inert salt. Too much emphasis cannot be placed on the word "mild," for while it is true that concentrated sodium hydrate or other strong alkali would form with the acid a neutral salt, yet the action of the same alkali is as dangerously caustic as is the acid for which it is intended as an antidote.

Most inorganic acids are prepared by the action of sulphuric acid on a salt of the acid which is desired. Sulphuric acid possesses a greater affinity for metals than most other acids, hence when a salt of the acid is treated with sulphuric acid, a sulphate is formed and the acid is liberated.

Reviewing the manufacture of official acids, we see how often this rule applies:

Hydrochloric acid, made from sodium chloride and sulphuric acid.
Hydrobromic " " " potassium bromide and sulphuric acid.
Nitric " " " sodium nitrate and sulphuric acid.
Chromic " " " potassium dichromate and sulphuric acid.
Carbonic " " " sodium bicarbonate and sulphuric acid.

Exceptions to this method are:

Phosphoric acid, made by oxidation of phosphorus with nitric acid.
Sulphurous " " reduction of sulphuric acid with carbon.

The officials treated in this chapter are:

Hydrochloric acid	containing	31 to 33	per cent.	of absolute	HCl.
Diluted hydrochloric acid	"	about 10	"	"	HCl.
Diluted hydrobromic acid	"	about 10	"	"	HBr.
Diluted hydriodic acid	"	about 10	"	"	HI.
Syrup of hydriodic acid	"	1	"	"	HI.
Nitric acid	"	67 to 69	"	"	HNO_3.
Nitrohydrochloric acid.					
Diluted nitrohydrochloric acid.					
Sulphuric acid	"	93 to 95	"	"	H_2SO_4.
Diluted sulphuric acid	"	about 10	"	"	H_2SO_4.
Aromatic sulphuric acid	"	about 20	"	"	H_2SO_4.
Phosphoric acid	"	85 to 88	"	"	H_3PO_4.
Diluted phosphoric acid	"	about 10	"	"	H_3PO_4.
Hypophosphorous acid	"	30 to 32	"	"	HPH_2O_2.
Diluted hypophosphorous acid	"	about 10	"	"	HPH_2O_2.

OFFICIAL ACIDS

ACIDUM HYDROCHLORICUM—Hydrochloric Acid

(Acid. Hydrochl.)

An aqueous solution containing not less than 31 per cent. nor more than 33 per cent. of HCl (36.47). Preserve it in glass-stoppered bottles.

Summarized Description.

Colorless fuming liquid; pungent odor; strongly acid to taste and to litmus; sp. gr. 1.155. For details see U.S.P., p. 13. For *tests for identity*, for *impurities* (as under diluted hydrochloric acid) and for *assay* see U.S.P., and also Part V of this book.

Remarks.—This is an aqueous solution of hydrochloric acid gas, containing 31 to 33 per cent. of absolute acid, and having a specific gravity of 1.16. Its two synonyms—*spirit of sea-salt* and *muriatic acid*—suggest its origin, the word muriatic being derived from the Latin *murias*, which means brine. As mentioned above, it is prepared by distilling a mixture of salt (sodium chloride) and sulphuric acid.

ACIDUM HYDROCHLORICUM DILUTUM—Diluted Hydrochloric Acid

(Acid. Hydrochl. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of HCl (36.47). Preserve it in glass-stoppered bottles.

Condensed Recipe.

Mix 100 Gm. hydrochloric acid with 220 Gm. distilled water.

Summarized Description.

Colorless, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.049. For details see U.S.P., p. 14. For *tests for identity*, for *impurities* (free chlorine, bromine, bromide and iodide, heavy metals, arsenic, sulphates, sulphurous acid) and for *assay* see U.S.P., p. 14, and also Part V of this book.

Diluted hydrochloric acid is prepared by mixing 100 Gm. of hydrochloric acid (U.S.P.) with 220 Gm. of water. It will be noticed that the preparation strictly follows the rules of dilution performed by alligation. The problem is to reduce a 32 per cent. acid to a 10 per cent. acid. Following general rules of alligation, we get:

32 − 10 = 22

10 − 0 = 10

10%

31.9 0%

10 (or water)

22

Summed up, we find that

10 Gm. of the official strong acid (31.9 per cent.)
and 22 Gm. of water (0 per cent.)
gives 32 Gm. of the diluted acid (10 per cent.).

Then, by proportion:

If to make 32 Gm. diluted acid we require 10 Gm. of strong acid; then to make 320 Gm. diluted acid we require $\frac{320}{32}$ × 10 or 100 Gm. stronger acid.

Or, expressed by equation:

$$32 : 10 :: 320 : x$$

$$x \text{ equals } \frac{10 \times 320}{32} \text{ equals 100 Gm.}$$

Hydrochloric acid, always in diluted form, is used in indigestion. *Dose.*—Of the diluted acid, 1 mil (15 minims).

ACIDUM HYDROBROMICUM DILUTUM—Diluted Hydrobromic Acid

(Acid. Hydrobrom. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of HBr (80.93). Preserve it in amber-colored, glass-stoppered bottles, protected from light.

Summarized Description.

Colorless, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.076. For details see U.S.P., p. 12.

For *tests for identity*, for *impurities* (non-volatile matter, sulphuric acid, barium, heavy metals, free bromine, iodine, arsenic, chlorides) and for *assay*, see U.S.P., p. 13 and also Part V of this book.

Remarks.—This official acid is a liquid containing 10 per cent. of absolute hydrogen bromide, and since an unstable chemical, should be dispensed as fresh as possible by the pharmacist. Hence efforts have been made to devise a simple method for its extemporaneous manufacture. The ordinary method of manufacture is by treatment of potassium bromide with sulphuric acid by the following reaction:

$$2KBr + H_2SO_4 = 2HBr + K_2SO_4.$$

From this equation it will be seen that the product of the reaction other than hydrobromic acid is potassium sulphate. This dissolves in water with the hydrobromic acid, and to separate the acid from the sulphate solution the tedious process of distillation is necessary. This led investigators to attempt the separation of the second reaction product from the acid by precipitation, in which case the acid could be obtained by simple filtration of the liquid from the precipitate. There are very few insoluble potassium salts, the best known being the bitartrate—cream of tartar—and this is utilized in the Fothergill process of making hydrobromic acid. In this, instead of using sulphuric acid with potassium bromide, tartaric acid is employed, and, on standing, the bitartrate crystallizes out, the reaction being:

$$\begin{array}{ccccccc} KBr & + & H_2C_4H_4O_6 & = & KHC_4H_4O_6 & + & HBr \\ 119 & & 150 & & 188 & & 80 \end{array}$$

The above equation implies the molecular proportion of 119 Gm. potassium bromide and 150 Gm. tartaric acid in making 80 Gm. hydrobromic acid. Then to make 1000 Gm. 10 per cent. hydrobromic acid (containing 100 Gm. absolute acid) will require $\frac{100}{80} \times 119$, or 148 Gm. potassium bromide and $\frac{100}{80} \times 150$, or 187 Gm. tartaric acid.

These proportions do not agree with the original recipe of Dr. Wade, who planned an acid each dram of which would contain the equivalent of 10 grains of bromine; nor with Dr. Fothergill's recipe, which was a cumbersome one, adapted to the Imperial system of measures; nor with the simpler recipe of Professor Maisch.

The latter recipe consists of 80 grains of potassium bromide dissolved in 6 fluidrachms water; 100 grains tartaric acid dissolved in 2 fluidrachms water; the solutions mixed and then chilled, in order to facilitate the separation of the cream of tartar. The difficulty in striking an exact recipe is due to the uncertainty of the amount of cream of tartar precipitated, and in the metric recipe given above, the total amount of water used should be 900 mils. Moreover, not more than 100 mils should be made at a time, since the product is not very stable.

It must be said that the product of this process is not absolutely pure acid; it always contains some potassium bromide and potassium bitartrate. Diluted hydrobromic acid is used as a sedative.

Dose.—1 mil (15 minims).

ACIDUM HYDRIODICUM DILUTUM—Diluted Hydriodic Acid

(Acid. Hydriod. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of HI (127.93). Preserve it in amber-colored, glass-stoppered bottles, protected from light, and do not dispense it if it contains free iodine.

Condensed Recipe.

Dissolve 135 Gm. potassium iodide and 10 Gm. potassium hypophosphite in 250 mils of distilled water. Dissolve 136.5 Gm. tartaric acid in 400 mils of diluted alcohol. Mix the two solutions, chill, filter through cotton, wash filter with diluted alcohol. Warm filtrate on water-bath until the alcohol has evaporated. Then add enough water to make 1000 Gm. For details see U.S.P., p. 11.

Summarized Description.

Colorless or faintly yellow liquid; odorless; strongly acid to taste and to litmus; sp. gr. 1.10. For details see U.S.P.

For *tests for identity*, for *impurities* (sulphuric acid, barium, free bromine and iodine, chlorides, heavy metals, arsenic) and for *assay* see U.S.P., p. 12 and also Part V of this book.

SYRUPUS ACIDI HYDRIODICI—Syrup of Hydriodic Acid

(Syr. Acid. Hydriod.)

One hundred mils of Syrup of Hydriodic Acid yields not less than 1.3 Gm. nor more than 1.45 Gm. of HI (127.93).

Condensed Recipe.

Mix 125 mils of diluted hydriodic acid with 300 mils of water and with enough syrup to make 1 liter.

Summarized Description.

Colorless or faint straw-colored fluid; odorless; sweet acidulous taste, sp. gr. 1.215. For details see U.S.P., p. 427.

For *tests for identity*, for *impurities* (free iodine) and for *assay* see U.S.P. and also Part V of this book.

Remarks.—Hydriodic acid, as mentioned on p. 389, is the binary acid of iodine. It is official in the present pharmacopœia in the form of diluted (10 per cent.) acid and the syrup (containing slightly more than 1 per cent. by weight of absolute hydriodic acid). The pharmacopœial method of the preparation of the diluted acid is a process devised by Dr. Buchanan, of Glasgow, and antedates the Fothergill-Wade process, which it closely resembles, the acid being liberated from potassium iodide by the addition of tartaric acid sufficient to precipitate potassium bitartrate, the equation being as follows:

$$KI + H_2C_4H_4O_6 = KHC_4H_4O_6 + HI.$$

The pharmacopœial recipe directs the addition of 1 per cent. of potassium hypophosphite, which is added to prevent, as far as possible, the separation of the iodine, which occurs when hydriodic acid is exposed to the air, the reaction being as follows:

$$2HI + O \text{ (from air)} = H_2O + I_2.$$

Potassium hypophosphite is supposed to recombine the liberated iodine with hydrogen by the following reaction:

$$KPH_2O_2 + 4I + 2H_2O = KI + 3HI + H_3PO_4.$$

This decomposition, as well as that of ferrous iodide, has been a subject of considerable discussion of late years (see p. 506), recent investigations seeming to show that the accepted idea that the decomposition is due to the separation of free iodine is erroneous. Haussmann claims that spoiled specimens of the syrup contain no free iodine, and that the change noticed is the conversion of the cane-sugar into glucose, which change is accompanied by side reactions, which produce the brown color. His theory, however, as far as syrup of ferrous iodide (p. 506) is concerned, is not in accord with facts, since if the brown tint is due to caramelization of sugar, the syrup could not be restored to its green tint by the introduction of a few card teeth, as really occurs. Since iodine is liberated under oxidizing action of air, it is advisable to avoid combination of the official acid or the syrup prepared therefrom with oxidizing agents; hence potassium chlorate should not be dispensed with the syrup.

The pharmacopœia of 1880 directed a method for the manufacture of the syrup of hydriodic acid different from that of the present pharmacopœia, the process of 1880 being to treat water in which iodine was suspended with hydrogen sulphide gas, the equation being as follows:

$$H_2S + I_2 = 2HI + S.$$

As a matter of fact, this process leads to a purer form of hydriodic acid than does the process of the present pharmacopœia, since the attempt to precipitate all the potassium salt as potassium bitartrate is not entirely successful, inasmuch as the bitartrate is somewhat soluble.

Both the diluted acid and the syrup are used as alteratives.

Dose.—Of diluted acid, 0.5 mil (8 minims). Of syrup, 4 mils (1 fluidrachm).

ACIDUM NITRICUM—Nitric Acid

(Acid. Nitric.)

An aqueous solution containing not less than 67 per cent. nor more than 69 per cent. of HNO_3 (63.02). Preserve it in dark amber-colored, glass-stoppered bottles and protect it from the light.

Summarized Description.

Fuming, caustic, corrosive liquid; suffocating odor; strongly acid to litmus; sp. gr. 1.403; volatilizes at 110°C.; dissolves metals with evolution of red-brown fumes; stains wool and the skin yellow. For details see U.S.P., p. 18.

For *tests for identity*, for *impurities* (non-volatile matter, arsenic, sulphuric acid, hydrochloric acid, heavy metals, iodine, bromine, iodic acid, bromic acid) and for *assay* see U.S.P., p. 18 and also Part V of this book.

Remarks.—Nitric acid is made by treating sodium nitrate with sulphuric acid and subsequent distillation. The official concentrated acid contains 68 per cent. of absolute acid, and has the specific gravity of 1.40. It was formerly largely dispensed under the synonym of *aqua fortis* (strong water), a synonym which, fortunately, is falling into disuse. The danger of the phrase is due to a confusion of it on prescriptions with *aqua fontana*, which means spring-water. Nitric acid is one of the most active of chemical substances, it being the most prominent oxidizing agent in general use. (See p. 398) Great care should be taken in handling it to avoid contact with the skin or clothing, as it acts as a very strong caustic on both, either destroying the fabric or staining it yellow.

Acidum Nitricum Dilutum (U.S.P. VIII) or *diluted nitric acid* is the above preparation diluted with water to a 10 per cent. preparation, the proportions following the rule of dilution by alligation.

Nitric acid is given highly diluted as a tonic and astringent.

Dose.—Of the diluted (10 per cent.) acid, 2 mils (30 minims).

ACIDUM NITROHYDROCHLORICUM—Nitrohydrochloric Acid

(Acid. Nitrohydrochl.—Nitromuriatic Acid)

A strong aqueous solution containing hydrochloric acid, nitric acid, nitrosyl chloride, and chlorine.

Condensed Recipe.

Cautiously mix 18 mils of nitric acid with 82 mils of hydrochloric acid.

Summarized Description.

Golden-yellow, fuming, corrosive liquid; smells of chlorine; dissolves gold leaf. For details see U.S.P., p. 18.

For *impurities* (non-volatile matter) see U.S.P.

ACIDUM NITROHYDROCHLORICUM DILUTUM—Diluted Nitrohydrochloric Acid

(Acid Nitrohydrochl. Dil.—Diluted Nitromuriatic Acid)

A diluted aqueous solution containing hydrochloric acid, nitric acid, nitrosyl chloride, and chlorine.

Condensed Recipe.

Cautiously mix 10 mils of nitric acid with 45.5 mils of hydrochloric acid and then dilute with enough water to make 250 mils. For details see U.S.P.

Summarized Description.

Colorless or pale-yellow liquid; faint odor of chlorine; strongly acid to taste and to litmus. For details see U.S.P., p. 19.

For *impurities* (non-volatile matter) see U.S.P.

Remarks.—Strong nitrohydrochloric acid is the *aqua regia* of the alchemists. Hydrochloric acid will not dissolve gold, neither will nitric acid; but the two combined have this power, hence the alchemistic name, which, translated, means the king of waters (*royal water*), since it dissolves gold, the king of metals. This special solvent power is due to presence, in the acid, of nitrosyl chloride, NOCl, and free chlorine.

Aqua regia is made by the direct combination of nitric and hydrochloric acids, the reaction being as follows:

$$HNO_3 + 3HCl = NOCl + Cl_2 + H_2O.$$

On figuring at the combining quantities used in the above equation and expressing same in terms of the official strength of the acid, it will be seen that the combining proportion is as follows:

Molecular Weight of Nitric Acid	*Molecular Weight of Hydrochloric Acid*	*Molecular Weight of Nitrosyl Chloride*	*Molecular Weight of Water*
H = 1	H = 1	N = 14	H_2O = 18
N = 14	Cl = 35.5	O = 16	*Molecular Weight of Chlorine*
O_3 = 48	HCl Mol. wt. = 36.5	Cl = 35.5	
HNO_3 Mol. wt. = 63	3 HCl = 109.5	NOCl = 65.5	Cl_2 = 71.

Repeating the equation:

$$\begin{array}{ccccccccc} HNO_3 & + & 3HCl & = & NOCl & + & Cl_2 & + & H_2O \\ 63 & & 109.5 & & 65.5 & & 71 & & 18, \end{array}$$

we see that the proportions expressed are 63 Gm. absolute (100 per cent.) HNO_3 and 109.5 Gm. absolute (100 per cent.) HCl. Then, how much 68 per cent. HNO_3 and how much 32 per cent. HCl will be needed? Taking up the nitric acid problem first, we find it will require $^{100}/_{68} \times 63$ Gm., which equals 92.6 Gm. nitric acid U.S.P. (68 per cent.).

As to the hydrochloric acid, we will need:

$^{100}/_{32} \times 109.5$ Gm., which equals 342.2 Gm. hydrochloric acid U.S.P. (32 per cent.). That is, 92.6 Gm. official nitric acid, sp. gr. 1.403 and 342.2 Gm. of hydrochloric acid, sp. gr. 1.155, are required to fulfil molecular proportions. Then, how many mils of each acid?

As to nitric acid:

1 mil water = 1 Gm.
1 mil nitric acid = 1.403 Gm.

Hence, 92.6 Gm. nitric acid equals 92.6 divided by 1.403, which equals 66 mils.

As to hydrochloric acid:

1 mil water = 1 Gm.
1 mil hydrochloric acid = 1.155 Gm.

Hence, 342.2 Gm. hydrochloric acid equals 342.2 divided by 1.155 equals 296+ mils. That is, nitrohydrochloric acid can be made by mixing 66 mils nitric acid U.S.P. with 296 mils hydrochloric acid U.S.P., or by union of 18 mils nitric acid with 81 mils hydrochloric acid:

$$66 : 296 :: 18 : x. \quad x = \frac{296 \times 18}{66} = 81$$

Comparison of these figures with the official recipe shows the latter provides slight excess of hydrochloric acid.

Diluted nitrohydrochloric acid is made by mixing 10 mils of nitric acid with 45.5 mils of hydrochloric acid, and after the reaction has ended, a sufficient quantity of water is added to make the official product measure 250 mils and contain the equivalent of 3.8 per cent. absolute nitric acid and 6.7 per cent. absolute hydrochloric acid—that is, about 10 per cent. mixed acids. At first glance it would be seen that the same results could be obtained by blending together the same proportion of diluted nitric acid and diluted hydrochloric acid as is directed of the two concentrated acids, and this without the necessity of adding extra water. But in practice the preparation must never be made by combining the acids in diluted form, as then they would have a simple mixture of the two acids and not a solution of nitrosyl chloride and chlorine.

This recalls the fact that chemical reaction usually occurs best in fairly concentrated solution; that the more diluted the solution, the slower and less violent the reaction, for violence of reaction means simply the accomplishment of a large amount of work in a short space of time. Accordingly, if it is known that a reaction is apt to be very violent, its dangers may be lessened by a proper dilution of the ingredients. Another valuable controller of violent reactions is judicious cooling of the vessel.

In mixing the strong acid, care must be exercised, else an effervescence of explosive violence will occur. The pharmacopœia directs that the mixing be done "in a capacious glass vessel" but a large evaporating dish is safer. Note that the pharmacopœia directs that the acid be stored in half-filled amber-colored bottles and states that the acid should not be dispensed if it fails to liberate iodine from potassium iodide solution.

Nitrohydrochloric acid is a hepatic stimulant when given in largely diluted doses. A prescription for liver troubles, formerly largely used, consisted of a mixture of fluidextract of taraxacum with the acid. When these two liquids are mixed, a violent effervescence occurs, due to the oxidation of some of the constituents of the fluidextract. In dispensing such preparations, therefore, care must be taken to avoid bottling until the effervescence ceases, as otherwise the liberated gases will cause an explosion of the bottle and the spattering of the acid mixture.

Dose.—Of strong acid, 2 decimils (3 minims). Of official diluted acid, 1 mil (15 minims).

SULPHURIC ACID

(H_2SO_4)

This well-known substance has been known since the fifteenth century, it being a matter of record that Basil Valentine obtained it by heating ferrous sulphate; from this origin is the synonym, *oil of vitriol*, derived. The alchemist had become familiar with several chemicals of crystalline form and of different colors, such as the sulphates of zinc, copper, and iron. By reason of their similarity to bright pieces of glass these substances were termed respectively *white vitriol* (vitrous meaning glass), *blue vitriol*, and *green vitriol*. All three of these "glasses," on being submitted to strong heat in a retort, yielded an oily liquid (sulphuric acid), which was, therefore, called oil of vitriol (or oil of glass).

As already explained the formula, H_2SO_4, is assigned this important acid. Oddo and Anneli state that estimations of its molecular weight points to the double formula $H_4S_2O_8$ and suggest a graphic formula showing this.

Sulphuric acid is the most important manufactured chemical used, being the veritable foundation of modern chemical industry; therefore its process of manufacture must be clearly comprehended.

The first stage is burning sulphur in contact with air, when there is formed sulphurous oxide, SO_2, whose suffocating odor is noticed in a burning sulphur match.

The second stage is the conversion of sulphurous oxide, SO_2, into sulphuric oxide, SO_3. This occurs by the process of oxidation—the adding of oxygen to a body—a process not so simple as it at first seems. We cannot change SO_2 into SO_3 by simply mixing with oxygen. To accomplish this we have to employ an energetic compound like nitric acid, chromium trioxide, or potassium permanganate. Let us explain the reason for this.

The change from SO_2 to SO_3 is not simply an addition of one more atom of oxygen; there is another and very important difference—that of valence of sulphur.

Sulphur in SO_2 is quadrivalent—has the valence IV—while in SO_3 it is sexivalent—has the valence VI—and to change sulphur with four bonds to sulphur with six bonds requires energetic action. So oxidation is not merely adding oxygen to a body, but in inorganic chemistry it almost invariably means change in the valence of one of the elements acted on.

In the sulphuric acid process we have completed the second stage, save giving the equation showing the reaction, which is:

$$3SO_2 + 2HNO_3 = 3SO_3 + N_2O_3 + H_2O.$$

In writing reactions always balance the finished equation to see if the same number of atoms are found on either side of the sign of equality. This is most important, for otherwise the equation is defective. Let us now run over the reasoning whereby the balancing is done. Write down the equation given above, checking off as we go along. 3S, in the SO_2 groups: on the other side of the equation we have 3S in the SO_3 groups, check them. $3 \times 2O$ in the SO_2 groups and $2 \times 3O$ in the HNO_3 groups;

that makes 12 O's in all. Let us look on the other side. 3 × 3O in the SO_3 groups; 1O in the H_2O and 2O in N_2O_2, they tally; so check them off. Then there are 2H in the HNO_3 groups, and on the other side there are 2H in H_2O; check off. Lastly, there are 2N in the HNO_3 groups, and across the equality line there are 2N in N_2O_2. When these are checked off, nothing unaccounted for remains on either side.

An interesting and useful point, especially in equation writing, is the amount of oxygen furnished by nitric acid in oxidation. $2HNO_3$ give three atoms of oxygen, as is shown in the following equation:

$$2HNO_3 \text{ breaks up into } \left\{\begin{array}{l} H_2\ \ O \\ \ \ N_2O_2 \\ \ \ \ \ \ \ O_3 \end{array}\right. \\ \overline{H_2N_2O_6} = 2HNO_3.$$

The third stage of the sulphuric acid reaction is very simple. The sulphuric oxide, SO_3, comes in contact with steam, H_2O, forming sulphuric acid, H_2SO_4.

In the second stage one of the products is N_2O_2. This readily takes oxygen from the air, even in the lead chamber, changing from a colorless vapor to the red-brown fumes, N_2O_4 or $2NO_2$. This N_2O_4 is brought in contact with fresh quantities of sulphurous oxide, which it oxidizes into sulphuric oxide by the following reaction: $2SO_2 + N_2O_4 = N_2O_2 + 2SO_3$.

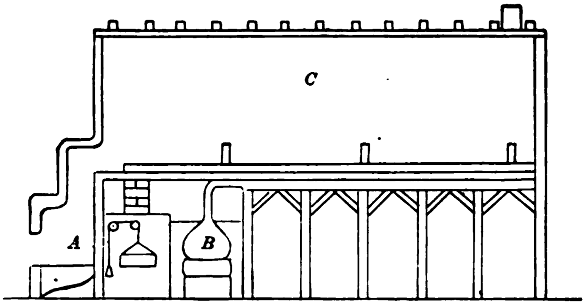


Fig. 232.—Lead-chamber (schematic): *A*, Sulphur furnace where reaction I takes place; *B*, retort where nitric acid is generated; *C*, lead-chamber where reactions II–VI occur.

The resulting N_2O_2 is again converted into N_2O_4, and thus the process is continuous, and a small quantity of nitric acid can be used over and over again in the oxidization process. Let us sum up the reaction in its five stages:

$$\begin{array}{rllll} \text{I.} & S & + O_2 & = & SO_2. \\ \text{II.} & 3SO_2 & + 2HNO_3 & = & 3SO_3 + H_2O + N_2O_2. \\ \text{III.} & SO_3 & + H_2O & = & H_2SO_4. \\ \text{IV.} & N_2O_2 \text{ (from II.)} & + O_2 & = & N_2O_4. \\ \text{V.} & 2SO_2 & + N_2O_4 & = & 2SO_3 + N_2O_2. \\ \text{VI.} & SO_3 & + H_2O & = & H_2SO_4. \end{array}$$

From this stage on the reaction is continuous, employing I, V, IV, and VI.

There are several intermediate stages in the reaction not shown in the equations just given. For instance SO_2 and N_2O_4 unite temporarily to form nitrosyl sulphuric acid, $SO_2\begin{matrix}\diagup OH \\ \diagdown ONO\end{matrix}$.

The appended sketch (Fig. 232) outlines the apparatus in which the reactions occur. The walls of the chamber are lined with lead; not because the metal is impervious to the acid, but because the lead sulphate formed is insoluble in water and sticks to the metal as a protective covering. Were zinc, copper, or iron employed, the sulphates of the metal, being soluble in water, would be dissolved off by the steam, constantly leaving a fresh metallic surface to be attacked.

While a deviation from the subject directly under consideration, this is perhaps the best place to emphasize the necessity of learning to write and balance equations correctly—those short-hand representatives of chemical reactions found on almost every page from where first introduced (p. 354). As an illustration of how *not* to write equations may be cited the following remarkable reaction actually submitted the writer by one of his pupils:

$$Zn + NaOH = H_2ZnSO_4!$$

How can a *sulphate* be formed when zinc and sodium hydrate are mixed? When we write, as we should—

$$Zn + 2NaOH = H_2 + Na_2ZnO_2,$$

we mean that if we combine 1 atom of zinc with 2 atoms sodium, 2 atoms oxygen, and 2 atoms hydrogen, we get, as the reaction products, 2 atoms hydrogen and also 2 atoms sodium, 1 atom zinc, and 2 atoms oxygen, and both besides must, of course, foot up the same.

To use a common comparison: if we take 4 apples, ½ pound sugar, and 1 pound flour to make a pie, the finished pie will surely not contain 8 apples, 1 pound sugar and 10 pounds of flour. Neither will it contain 4 apples and a pound of baking soda. Use, in writing equations, the same common sense employed in discussing an ordinary apple-pie, remembering that a chemical reaction is merely a rearrangement of matter, and during such a change matter is neither created nor lost. While on the subject it may be well to emphasize the three varieties of reactions by giving equations expressing their character:

A *simple reaction* is one in which two elements combine to form a compound, thus: $H_2 + O = H_2O$.

A *simple decomposition* is a reaction in which an element acts on a compound in such manner as to break it up and then form a new compound, thus: $K + H_2O = KOH + H$.

A *double decomposition* is a reaction in which two compounds so act on each other as to form two new compounds, thus: $KOH + HCl = H_2O + KCl$.

To return to sulphuric acid, besides obtaining sulphurous oxide by burning sulphur in air, the same gas is obtained by the burning of iron pyrites (see p. 499), and in technic this substance is largely used for the production of sulphuric acid in place of sulphur. The objection to this so-called "pyrites acid" is that the native pyrites usually contain arsenic, and the acid obtained therefrom is frequently contaminated with this deleterious substance. Careful manufacturers, however, succeed in removing all traces of arsenic by treatment of the crude acid with hydrogen sulphide, the excess of which is removed from the acid by heating. According as to whether sulphur or iron pyrites is employed in the manufacture of the sulphuric acid, specially constructed furnaces are employed. It might here be said that the limitations of this work preclude entering into details of technic of the manufacture of all the chemicals here described; the student desiring such is referred to standard works on chemical technology found in the preface.

Of recent years, the *contact method* of manufacture of sulphuric acid has come into use. In this process the oxidation of sulphurous oxide to sulphuric oxide is accomplished by passing a mixture of the first-named oxide and of air over spongy platinum heated to 400°–450°C., thus avoiding the use of nitric acid—the air furnishing the required oxygen and the platinum bringing about the chemical action. The process is a commercial success, and is still operated under patents.

Sulphuric acid is the most important manufactured chemical known to the world, it being used in numberless branches of trade. An indications of its enormous consumption is the statement that in this country over two to three million tons are made each year.

Three forms of sulphuric acid are recognized by the pharmacopœia:

ACIDUM SULPHURICUM—Sulphuric Acid

(Acid. Sulphuric.)

A liquid containing not less than 93 per cent. nor more than 95 per cent. of H_2SO_4 (98.09). Preserve it in glass-stoppered bottles.

Summarized Description.

Colorless, odorless, oily liquid; very caustic and corrosive; sp. gr., 1.83; miscible with water and with alcohol, with evolution of much heat; vaporizes with evolution of dense fumes. For details see U.S.P., p. 24.

For *tests for identity*, for *impurities* (lead, nitric or nitrous acids, hydrochloric acid, heavy metals, non-volatile matter, sulphurous acid, arsenic) and for *assay* see U.S.P., p. 24 and also Part V of this book.

Remarks.—This contains 93 to 95 per cent. of the absolute acid, and has the specific gravity 1.83, which represents the greatest strength of acid convenient for manufacturing and handling. This acid is a colorless liquid, of oily consistence, miscible in all proportions of alcohol and water with the evolution of so much heat that mixing requires great caution

ACIDUM SULPHURICUM DILUTUM—Diluted Sulphuric Acid

(Acid. Sulph. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of H_2SO_4 (98.09). Preserve it in glass-stoppered bottles.

Condensed Recipe.

Pour 50 Gm. sulphuric acid cautiously into 420 Gm. distilled water. For details see U.S.P.

Summarized Description.

Colorless, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.067. For details see U.S.P., p. 25.

For *tests for identity*, for *impurities* (non-volatile matter, sulphurous, nitrous and hydrochloric acids, heavy metals and arsenic) and for *assay* see U.S.P., p. 25 and also Part V of this book.

Remarks.—This diluted form contains about 10 per cent. absolute H_2SO_4. As mentioned above, the dilution of the strong acid with either alcohol or water must be performed with care, as great heat is evolved, frequently resulting in a spattering of the hot acid. A rule always to be observed in diluting sulphuric acid is that the acid should be poured in a fine stream into the water contained in a shallow dish. Never should water be poured into the acid, and rarely is it advisable to perform the dilution of the acid in anything but a shallow open dish.

Medical Properties.—Used like aromatic sulphuric acid. The concentrated is never used medicinally except after dilution.

Dose.—1 mil (15 minims).

ACIDUM SULPHURICUM AROMATICUM—Aromatic Sulphuric Acid

(Acid. Sulph. Arom.)

Aromatic Sulphuric Acid contains free sulphuric acid and ethylsulphuric acid together equivalent to not less than 19 per cent. nor more than 21 per cent. of H_2SO_4 (98.09). Preserve it in glass-stoppered bottles.

Condensed Recipe.
See below.

Summarized Description.
Clear, reddish-brown liquid; aromatic odor; sp. gr. 0.933. For details see U.S.P., p. 24.
For *tests for identity*, and for *assay* see U.S.P., p. 25 and also Part V of this book.

Remarks.—This pharmaceutic is made by adding 109 mils of the concentrated acid to 700 mils alcohol, and when the mixture is cooled, there is added 50 mils of tincture of ginger, 1 mil of oil of cinnamon, and enough alcohol to make the finished product measure 1000 mils.

At the first glance the above recipe would indicate a 10 or 11 per cent. acid, but when it is recalled that the 100 mils of sulphuric acid will weigh 183 Gm., while 100 mils alcohol weighs but 82 Gm., it will be seen that the strength by weight is about 20 per cent. This preparation is known as *elixir of vitriol,* and replaces the original recipe, which was popular for several hundred years. The preparation contains, besides sulphuric acid, some ethyl-sulphuric acid. (See p. 593.)

Aromatic sulphuric acid affords the favorite means of administration of the acid, its chief use being in the night-sweats of tuberculosis.

Dose.—1 mil (15 minims).

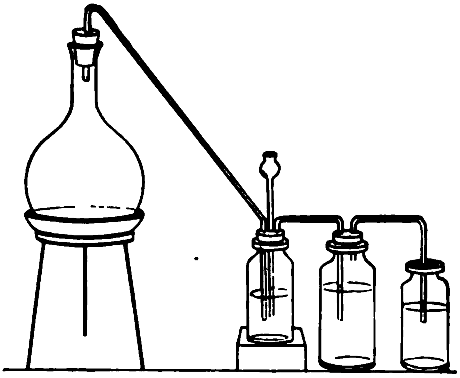


Fig. 233.—Apparatus for manufacture of sulphurous acid.

Nordhausen sulphuric acid is a form of acid obtained by distilling completely exsiccated ferrous sulphate or roasted iron pyrites in dry retorts. It consists of a mixture of H_2SO_4 and SO_3, and is, therefore, sometimes assigned the formula $H_2S_2O_7$. A semisolid modification now in commerce consists almost entirely of SO_3. *Oleum* is a liquid mixture of H_2SO_4 and SO_3 obtained by the contact process.

Acidum Sulphurosum (U.S.P. VIII) or *sulphurous acid,* is a saturated aqueous solution of sulphurous oxide, containing 6 per cent. SO_2. In common with all ternary acids, this body is derived from the corresponding oxide, sulphurous oxide, which we have already learned is SO_2, and this combines with water, as shown in the following equation:

$$SO_2 + H_2O = H_2SO_3.$$

While theoretically all ternary acids are derived from the oxides by treatment with water, in the practical manufacture of ternary acids this method is not always evident. For instance, in the Markoe process of manufacture of phosphoric acid (p. 404) the formation of the oxide, while occurring, is not expressed in the equation. Sulphurous acid, however, is manufactured by the direct solution of sulphurous oxide gas in water, this gas being obtained by the reduction of sulphuric acid.

Two operations—oxidation, or the addition of oxygen to a body, and reduction, or the removal of oxygen from a substance—are very important operations in chemical work.

Substances capable of increasing the valence of an element at the same time it gives oxygen to the element are called oxidizing agents, and, on a preceding page, nitric acid, potassium permanganate, and chromic acid were cited as oxidizing agents. A reducing agent, on the other hand, takes oxygen from a body and reduces the valence of one of its elements. Carbon (charcoal), metallic sodium (chiefly as sodium alcoholate), and glucose are examples of reducing agents, and usually in inorganic chemistry carbon is employed. This is true in the manufacture of sulphurous acid, in which the reaction is as follows:

$$H_2SO_4 = SO_3 + H_2O$$
$$2SO_3 + C = 2SO_2 + CO_2.$$

Both gases formed, sulphurous oxide and carbonic oxide, after washing—after passing through a flask containing water, which will absorb such soluble impurities as sulphuric oxide—are run into cooled distilled water, which dissolves the sulphurous oxide (forming corresponding acid), while most of the carbon dioxide passes off. Since the process affords a striking illustration of the apparatus required in the manufacture, washing, and collecting of gases, a picture of the apparatus is here given (Fig. 233). Sulphur dioxide and sulphurous acid are employed because of their reducing action, both abstracting oxygen from many substances with which they come in contact. It is because of this property that these bodies are used as bleaching agents and as disinfectants, and it is because of the latter action that the official acid is of value in medicine. Sulphurous acid is sometimes used internally as an antiferment. It soon loses the dissolved sulphurous oxide, hence should be dispensed only in the fresh state.

Dose.—2 mils (30 minims).

ACIDUM PHOSPHORICUM—Phosphoric Acid

(Acid. Phos.)

A liquid containing not less than 85 per cent. nor more than 88 per cent. of H_3PO_4 (98.06). Preserve it in glass-stoppered bottles.

Summarized Description.

Colorless, odorless, syrupy liquid; strongly acid to taste and to litmus; sp. gr. 1.72; on heating it is converted into pyrophosphoric acid and then into metaphosphoric acid. For details see U.S.P., p. 21.

For *tests for identity*, for *impurities*, see diluted phosphoric acid. For *assay* see U.S.P., p. 21 and also Part V of this book.

Remarks.—Phosphoric acid is recognized by the pharmacopœia in the form of an 85 to 88 per cent. solution, the so-called "syrupy phosphoric acid." It is made by the oxidation of phosphorus with nitric acid, a process accompanied by some danger, hence the recipe is omitted in the present pharmacopœia, since the chemical can be best and most cheaply prepared by the large manufacturer. The equation of the reaction is

$$6P + 10HNO_3 = 3P_2O_5 + 5H_2O + 5N_2O_2$$
$$P_2O_5 + 3H_2O = H_6P_2O_8 = 2H_3PO_4.$$

Let us go over the reasoning employed in figuring out these quantities. We want to make P_2O_5; we need for this five atoms of oxygen. We have learned that $2HNO_3$ yield three atoms of oxygen; three is not divisible into five; hence to make P_2O_5 will require the amount of oxygen from nitric acid corresponding to the least common multiple of three and five. This is fifteen. Fifteen atoms of oxygen are needed; $2HNO_3$ yield three atoms oxygen; hence to furnish 15O will require $5 \times 2HNO_3$ or $10HNO_3$.

We are making P_2O_5. One molecule of this contains five atoms of oxygen. We have fifteen atoms of oxygen; hence can make $3P_2O_5$; for $3 \times 5O = 15O$. Lastly, we see that in $3P_2O_5$ there are six phosphorus; hence we begin the equation with six atoms of phosphorus and ten molecules of nitric acid.

If to one molecule of P_2O_5 we add one molecule of H_2O, we get two molecules of metaphosphoric acid, HPO_3. If, on the other hand, as above, we add three molecules H_2O to one molecule of P_2O_5, we get two molecules of the official (so-called ortho-) phosphoric acid, H_3PO_4.

A less dangerous method of manufacture than that just given, devised by Professor Markoe for the use of the retail pharmacist, consisted in treating phosphorus under the surface of water with bromine and a small quantity of iodine, and at the end of the reaction nitric acid is added. The reaction runs in three distinct stages. First, phosphorus and bromine unite to form phosphorus pentabromide, viz.:

$$\text{(I)}\quad P + Br_5 = PBr_5.$$

This decomposes in the presence of water, with the formation of phosphoric acid and hydrobromic acid:

$$\text{(II)}\quad PBr_5 + 4H_2O = H_3PO_4 + 5HBr.$$

The nitric acid liberates bromine from hydrobromic acid:

$$\text{(III)}\quad 6HBr + 2HNO_3 = Br_6 + 4H_2O + N_2O_3.$$

The bromine here freed acts on another portion of the phosphorus, and the reactions I, II, and III are repeated in regular order as long as any phosphorus remains unoxidized.

It will be seen that the ultimate result of this process is the same as that of the first process, nitric acid being the real oxidizing agent in both cases. The function of the bromine in the second process is to lessen the violence of the reaction by gently bringing the nitric acid in contact with the phosphorus, insuring a gradual evolution of the gaseous nitrogen dioxide; for be it remembered that most explosions are due either to a sudden evolution or a sudden contraction of a gas. If the process is so planned to permit the evolution of a gas during several hours, no danger ensues, but if the same amount of gas is evolved in a few moments, a violent explosion occurs (p. 422).

In both processes the liquid remaining at completion of reaction is evaporated, partly to remove the last traces of nitric and nitrous acids (also bromine, in last process), and also to concentrate the product to the official strength. The last task is very tedious if carried out in an open evaporating dish, and in the writer's experience he has never succeeded in making an acid of pharmacopœial strength, the strongest he produced being about 65 per cent. Under the pharmacopœia of 1880, where a 50 per cent. acid was directed, the Markoe process was feasible for the retail pharmacist, but now that the pharmacopœia demands the more concentrated form, we are brought back to the original proposition that the pharmacist had better purchase his phosphoric acid. Much of the phosphoric acid of commerce contains arsenic, and the origin of this impurity is of interest as showing how persistently impurities may sometimes cling to chemicals, even though the original substance has undergone several changes. The arsenic in the phosphoric acid is due to arsenic-contaminated phosphorus. The phosphorus obtains it from arsenic-contaminated sulphuric acid, while the sulphuric acid contaminated with arsenic is usually that manufactured from iron pyrites, in which the arsenic originally occurred. It, therefore, behooves every careful pharmacist to test both his phosphoric acid and his sodium phosphate for arsenic by the tests prescribed in the pharmacopœia. (See Part V.)

ACIDUM PHOSPHORICUM DILUTUM—Diluted Phosphoric Acid
(Acid. Phos. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of H_3PO_4 (98.06). Preserve it in well-stoppered bottles.

Condensed Recipe.

Mix 100 Gm. phosphoric acid with 765 Gm. distilled water.

Summarized Description.

Clear, colorless, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.057. For details see U.S.P., p. 21.

For *tests for identity*, for *impurities* (metaphosphoric and pyrophosphoric acids; phosphorous, hypophosphorous, sulphuric and nitric acids; heavy metals, arsenic and phosphates) and for *assay* see U.S.P., p. 21 and also Part V of this book.

Remarks.—This body represents the strong acid diluted with a sufficient quantity of water to make it contain 10 per cent. of absolute H_3PO_4. These two acids are employed as nervous stimulants, although for such purpose that popular remedy, *acid phosphates*, is more frequently employed. A recipe for this preparation may be found in the National Formulary under the title of *liquor acidi phosphorici*. (See p. 384.)

It will be observed that the theoretic construction of the phosphoric acid is based on the addition of three molecules of water to one molecule of phosphoric oxide, this yielding H_3PO_4—the so-called orthophosphoric acid. As explained on p. 358, this substance is not the true "ortho-" acid. If the same oxide is combined with one molecule of water, the following reaction occurs:

$$P_2O_5 \ + \ H_2O \ = \ 2HPO_3,$$

metaphosphoric acid being formed. This metaphosphoric acid is called *glacial phosphoric acid*, because on cooling it becomes a transparent, ice-like solid.

Under this division mention may be made of *pyrophosphoric acid*, $H_4P_2O_7$. The composition of this body will be considered when discussing sodium pyrophosphate (p. 441), and mention is here made merely to call attention to the test distinguishing between the three forms, *ortho-*, *meta-*, and *pyro*-phosphoric acids, these three being also called respectively the tribasic, monobasic, and the tetrabasic phosphoric acids. (See p. 359.) Orthophosphoric acid does not coagulate albumin (white of egg), and forms a yellow precipitate of silver phosphate on the addition of silver nitrate solution. Metaphosphoric acid coagulates albumin, and gives a white precipitate with silver nitrate, while pyrophosphoric acid does not coagulate albumin, and gives a white precipitate with silver nitrate. Silver nitrate reactions also apply to the salts of these acids, but the albumin test can be used only with the free acids.

Dose.—2 mils (30 minims).

Liquor Phosphatum Acidus (N.F.) or *solution of acid phosphates* is now made by dissolving precipitated chalk and magnesium carbonate in a diluted phosphoric acid, the former method of preparation from bone ash (p. 384) being abandoned.

Liquor Phosphatum Compositus (N.F.) is discussed on p. 191.

ACIDUM HYPOPHOSPHOROSUM.—Hypophosphorous Acid (Acid. Hypophos.)

An aqueous solution containing not less than 30 per cent. nor more than 32 per cent. of HPH_2O_2 (66.06). Preserve it in glass-stoppered bottles.

Summarized Description.

Colorless or faint-yellow, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.13; on heating it decomposes into phosphine and phosphorous acid. For details see U.S.P., p. 15.

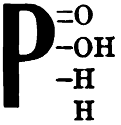
For *tests for identity*, for *impurities*, see diluted hypophosphorous acid. For *assay* see U.S.P., p. 16 and also Part V of this book.

Remarks.—This official contains 30 to 32 per cent. of absolute hypophosphorous acid. The usual method of manufacture is by a modification of the Fothergill process, potassium hypophosphite being treated with enough tartaric acid to precipitate all the potassium in the form of insoluble potassium bitartrate. Among other processes which have been suggested is the treatment of calcium hypophosphite with oxalic acid or ammonium oxalate in which case the following reaction occurs:

$$Ca(PH_2O_2)_2 + H_2C_2O_4 = 2HPH_2O_2 + CaC_2O_4.$$

the calcium oxalate being then filtered from the solution of the acid. A third process is by treatment of barium hypophosphite with sulphuric acid, precipitated barium sulphate being removed by filtration.

The pharmacopœia writes the formula of hypophosphorous acid HPH_2O_2. This is because it has but one replaceable hydrogen. Its composition has been the subject of considerable discussion, but now its graphic formula is supposed to be



$$\mathrm{P}\begin{array}{l}=\mathrm{O}\\-\mathrm{OH}\\-\mathrm{H}\\\ \ \mathrm{H}\end{array}$$

The valence of phosphorus is five, just as in phosphoric acid. This is totally different from what we usually find in various acids of the same element, and constitutes one of the weak points in the valence theory.

ACIDUM HYPOPHOSPHOROSUM DILUTUM—Diluted Hypophosphorous Acid (Acid. Hypophos. Dil.)

An aqueous solution containing not less than 9.5 per cent. nor more than 10.5 per cent. of HPH_2O_2 (66.06). Preserve it in well-stoppered bottles.

Condensed Recipe.

Mix 100 Gm. hypophosphorous acid with 210 Gm. distilled water. For details see U.S.P., p. 160.

For *tests for identity*, for *impurities* (barium, oxalic acid, heavy metals, arsenic) and for *assay* see U.S.P., p. 16 and also Part V of this book.

Summarized Description.

Colorless, odorless liquid; strongly acid to taste and to litmus; sp. gr. 1.042. For details see U.S.P., p. 16.

Remarks.—This 10 per cent. acid is directed in the present pharmacopœia to be made by diluting the official stronger acid. Diluted hypophosphorous acid is official because a constituent of syrup of hypophosphites. It is rarely used alone, but when it is, its action is similar to that of the better-known hypophosphites of the alkalies.

Dose.—5 decimils (8 minims).

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CHAPTER XXV

THE METALS—POTASSIUM

The elements thus far considered are grouped in the class which are called non-metals or metalloids. As already mentioned, however, a sharp distinction between the positive and the negative elements is a matter of considerable difficulty, and even so it is difficult to decide whether a given element is metallic or non-metallic. In choosing a definition for the *metals*, about all that can be said is that those substances are metals which possess a metallic lustre and which are good conductors of electricity. Their oxides, when they dissolve in water, usually have an alkaline reaction, although several of the elements which we are now to consider will be found to possess oxides which are more acid than basic. It, therefore, resolves the definition to the one statement that metals are good conductors of electricity.

The alkaline metals are the group of elements, lithium, sodium, and potassium, to which is added the radical, ammonium (NH_4), it possessing properties so similar to the three metals just mentioned that its compounds are considered with them. It might be added, too, that the rare elements rubidium and cæsium belong to this group, but since they have no pharmaceutic application, nothing need be said of them in this work.

These alkaline metals possess many characteristics in common. They all possess the valence I, are soft and easily oxidizable substances, and are the only metals whose carbonates are soluble in water. This fact is used in analytic chemistry for separating the salts of these four metals from the other metals, as will be seen in Part V.

POTASSIUM

Symbol, K. Atomic weight, approximately 39

This element is found in *carnallite*, which is a mixture of potassium and magnesium chlorides, and in *sylvite*, which is chiefly potassium chloride—these two ores are obtained from the mines of Stassfurt, Germany. Another source of potassium is *suint*, or the washings of wool. The freshly sheared wool is roughly cleaned by washing in water, the washings are then concentrated, and from them is obtained wool-fat by extraction with the proper solvent. In the residue is found potassium in sufficiently large amounts to be a commercial source of the element. Potassium carbonate is also extracted from the residues in the manufacture of beet-sugar (*vinasse*), while large amounts are obtained from ashes of wood by lixiviation. Lately attempts have been made to obtain potassium salts from sea weed.

Potassium was isolated by Sir Humphrey Davy in 1807 in his classic researches in electricity. He submitted potassa to electrolysis, placing a small lump on a piece of platinum foil, which was then connected with the negative pole of the battery. Bringing the positive pole in contact with the potassa the latter dissociated and small globules of metallic potassa were formed.

The electrolysis of potassium in Davy's day was too expensive a process for commercial application, and the metal was first produced commercially by Brunner by another process—by heating potassium carbonate with carbon in a retort to 1000°C., when potassium and carbon monoxide were produced, as shown in the following equation:

$$K_2CO_3 + C_2 = K_2 + 3CO.$$

This process is accompanied with danger, inasmuch as carbon monoxide forms with potassium, as well as with several other metals (copper, for example), well-defined solid carbonyl derivatives. In the isolation of potassium the carbonyl, KCO, clogs up the delivery tube leading from the retort, and with the stoppage of this outlet explosion of the retort occurs. This danger has been avoided by arranging the apparatus, whereby a plunger is made to fit in the delivery tube, and by passing this plunger up and down the obstructions were removed. It should have been stated that the delivery tube terminates in a vessel containing liquid petroleum or benzin, in order that the potassium will be condensed in a medium by which it is not affected, and which will protect it from atmospheric action.

Potassium is now being made on a large scale by electrolysis of potassium hydroxide, the reduction in the cost of the production of electricity since Davy's day permitting the commercial application of Davy's process.

Potassium is a silvery metal lighter than water and of the consistence of wax, hence it can be readily cut with a knife. A freshly cut surface, after exposure to air, becomes white and granular, due to the formation of the potassium carbonate. Metallic potassium combines so readily with oxygen that when exposed to the air the action is so energetic that the metal burns. Likewise, when the metallic potassium is thrown on the surface of water it combines with the same, forming potassium hydroxide, as shown in the following equation:

$$K + H_2O = KOH + H,$$

and the heat of the reaction is sufficient to cause an ignition of the hydrogen, which burns with explosive violence. Hence great care should be taken in the handling of potassium, and particular caution must be exercised in combining same with water. For this reason the metallic potassium is always kept under substances devoid of oxygen, such as benzin or petroleum.

The statements just given emphasize the care to be used in handling potassium. In weighing it one rapidly cuts from the piece the oxidized exterior and then presses the pure metal of the interior rapidly between filter-paper to remove the last traces of the liquid in which it has been kept. Thus it can be weighed upon a watch-glass, although in cases of large quantities it is best to weigh same under petroleum, leaving the drying of the metal until it has been weighed.

The tests for potassium are, first, the characteristic crystalline precipitate that potassium salts yield with platinic chloride. The separation of this precipitate is facilitated by the addition of a few drops of alcohol to the concentrated aqueous solution. Another test is the white, crystalline precipitate of cream of tartar, produced when a potassium salt is brought in contact with the proper quantity of tartaric acid, as shown in the following equation:

$$KCl + H_2C_4H_4O_6 = KHC_4H_4O_6 + HCl.$$

One of the most sensitive tests is the violet tint imparted to a colorless flame.

THE OFFICIAL COMPOUNDS AND PREPARATIONS OF POTASSIUM

Potassium acetate, 99 per cent. absolute $KC_2H_3O_2$.
Potassium bicarbonate, 99 per cent. absolute $KHCO_3$.
Potassium bitartrate, 99.5 per cent. absolute $KHC_4H_4O_6$.
Potassium bromide, 98.5 per cent. absolute KBr.
Potassium carbonate, 99 per cent. absolute K_2CO_3.
Potassium chlorate, 99 per cent. absolute $KClO_3$.
Lozenges of potassium chlorate. Pharmaceutic.
Potassium citrate, 99 per cent. absolute $K_3C_6H_5O_7H_2O$.
Effervescent potassium citrate contains 20 per cent. official citrate.
Solution of potassium citrate contains 8 per cent. anhydrous citrate.
Potassium and sodium tartrate, 99 per cent. absolute $KNaC_4H_4O_64H_2O$.
Potassium hydroxide, 85 per cent. absolute KOH.
Solution of potassium hydroxide contains not less than 4.5 per cent. absolute KOH.
Potassium hypophosphite, 98 per cent. absolute KPH_2O_2.
Potassium iodide, 99 per cent. absolute KI.
Potassium nitrate, 99 per cent. absolute KNO_3.
Potassium permanganate, 99 per cent. absolute $KMnO_4$.
Sulphurated potassa, 12.8 per cent. S.

We might also add—

Aluminum and potassium sulphate (considered among the aluminum salts).
Solution of potassium arsenite (considered among the arsenic salts).

In going over the preparations of each metal we can usually note a certain salt of the metal that is used in making the other salts of the same metal. Thus, with the alkalies the carbonates are the salts usually employed. The salt thus selected as a "stock salt" is chosen for the most practical reasons. Among the deciding factors, cheapness and easy decomposition are the most important. Thus, with the alkalies, the chlorides are the most abundant salts, but since they are not easily decomposed, they are converted into carbonates, which are generally used. But besides these two factors other considerations come into play. Thus, in making potassium compounds the carbonate itself is not usually employed, because it is quite deliquescent and difficult to purify, therefore the bicarbonate, which occurs in handsome crystals, is selected. Hence, mere cheapness is not the absolute guide in the choice of material, but utility, average purity, and ease of action are among the other factors considered.

POTASSII HYDROXIDUM—Potassium Hydroxide

(**Pot. Hydrox.**—Caustic Potash—Potassium Hydrate)

It contains not less than 85 per cent. of KOH (56.11). Preserve it in well-closed containers. If bottles are used they must be made of hard glass.

Summarized Description.

White flakes, fused masses or brittle sticks; very caustic; deliquescent in air, absorbing both water and carbon dioxide; soluble in 0.9 part of water and 2.4 parts, of alcohol; strongly alkaline. For details see U.S.P., p. 338. For *tests for identity*, for *impurities* (heavy metals, organic matter, insoluble matter) and for *assay* see U.S.P., p. 339 and also Part V of this book.

Remarks.—The official chemical must contain at least 85 per cent. potassium hydroxide, a 100 per cent. specimen being almost impossible except when just solidified, as it rapidly absorbs water from the air.

Potassium hydroxide is usually made by the evaporation of a solution of potassa, the manufacture of which will be given below. Official potassa usually comes into the market in the form of cylindric sticks, about ½ inch in diameter, these being made by melting the potassa and pouring into molds. The fusion of the potassa is an operation which must be carefully conducted, as the molten mass makes a very painful burn.

Potassa is very deliquescent, and therefore must be kept in well-stoppered bottles. It is a practice, on the first opening of a bottle of potassa, to seal it with a considerable quantity of wax, so that on opening at later periods an air-tight joint can be renewed by simply passing a hot spatula over the wax.

Potassa is considerably used in chemical manufacturing, as will be noted in the following pages. Its volumetric solution (see Part V), is used for estimating the strength of acids. Medicinally, potassa is used externally as a caustic, the official sticks being brought in direct contact with the surface desired to be burned. Its action, however, is so severe that in modern medicine its use is comparatively rare. The internal administration of potassa is always in the form of the official solution.

It will be noted that the present pharmacopœia calls potassia "potassium hydroxide," and not potassium hydrate, the same rule being true of all metallic hydrates. (See Sodium Hydroxide, Ferric Hydroxide, etc.) This is in line with the modern chemical nomenclature, which attempts to limit the word hydrate to water of crystallization. (See p. 150.)

Lye is supposedly crude potassium hydroxide, although much of the commercial lye is sodium hydroxide. While not as pure as the official variety, it is frequently stronger than 85 per cent.

Potassa cum Calce (U.S.P. 1890; N.F. IV) represents the official potassa diluted with its own weight of freshly burned lime, the two being rubbed together in a warm iron mortar until a powder is formed. This preparation is supposed to be used as a caustic in preference to the pure potassa. It is never used internally.

LIQUOR POTASSII HYDROXIDI—Solution of Potassium Hydroxide

(**Liq. Pot. Hydrox.**—Liquor Potassæ—Solution of Potassa)

An aqueous solution containing not less than 4.5 per cent. of KOH (56.11). Preserve Solution of Potassium Hydroxide in bottles made of hard glass, and provided with rubber stoppers or with glass stoppers coated with petrolatum.

Condensed Recipe.

Dissolve 60 Gm. potassium hydroxide in 940 Gm. water. For details see U.S.P.

Summarized Description.

Clear, colorless, odorless liquid; caustic; strongly alkaline; absorbs carbon dioxide from the air; sp. gr. 1.046. For details see U.S.P., p. 252.

For *tests for identity*, and for *impurities* see potassium hydroxide. For *assay* see U.S.P., p. 252 and also Part V of this book.

Remarks.—This preparation, commonly called *solution of potassa*, is now directed to be made by the simple solution of stick caustic potash (potassium hydroxide of the present pharmacopœia) in water. The recipe of the U.S.P. 1890, given in detail in Part VII, consists of a double decomposition between potassium bicarbonate and calcium hydroxide, as shown in the following equation:

$$KHCO_3 + Ca(OH)_2 = CaCO_3 + KOH + H_2O.$$

Let us make this, if possible, still clearer by graphic expression:

Potassium bicarbonate		*Calcium hydrate*		
K		OH		KOH Potassium hydrate.
H	+	OH	=	HOH Water.
CO_3		Ca		$CaCO_3$ Calcium carbonate.
$KHCO_3$		$Ca(OH)_2$		

Note that in figuring out these processes it is the practical, rather than the theoretic, side that is considered. The compounds used are always the cheapest that will answer satisfactorily. Thus in the process just given, magnesium hydroxide could be used just as well as that of calcium, but it is not so employed merely because it is no better for the purpose than slaked lime and it costs much more.

It will be noticed that the calcium is removed in the form of an insoluble calcium compound, leaving nothing in solution but potassium hydroxide, provided that the proper molecular proportions are employed.

Solution of potassa is a colorless liquid, having a very acrid caustic taste and strongly alkaline reaction. It is so strongly alkaline that it attacks the glass of the bottles in which it is kept, forming therein a precipitate of potassium silicate. For the same reason it causes the glass stopper to adhere to the neck of the bottle. Therefore, if the solution is kept in glass-stoppered bottles, the stoppers should be protected by being smeared with petrolatum.

For the purposes of the practical pharmacist the method of manufacture of the present pharmacopœia is better than the chemical process given above, as large quantities of the solution of potassa should not be kept on hand, owing to the fact that it rapidly deteriorates in strength, and the present official process affords an easy method of making up small quantities.

Solution of potassa is used as an antacid.

Dose.—1 mil (15 minims) largely diluted in water.

In cases of poisoning by potassa or its solution the antidote is that used for all caustic alkalies, namely, a mild acid, such as vinegar or lemon-juice.

Note that *potassium* and *potassa* are not the same. Potassium is the element—the light alkali metal of the symbol K. Potassa, or caustic potash, is the hydroxide of potassium, its formula being KOH. Abandon the antiquated habit of saying "chlorate of potash," "carbonate of potash," and so on. Say "potassium chlorate," or "potassium carbonate," and thus have labels printed, gradually educating the public. The question of label printing deserves more time than is usually given it. We take the labels as the printer sees fit to spell them, because, forsooth! they are cheap.

Shop labels should follow pharmacopœial changes, and in so doing it is best to have both the old and the new names on the label, as suggested below; for some conservative people would be suspicious were only the new name on the label. The suggested label is as follows·

POTASSIUM CHLORATE.

(Chlorate of Potash.)

POTASSA SULPHURATA—Sulphurated Potassa

(Pot. Sulphurat.—Liver of Sulphur)

A mixture composed chiefly of potassium polysulphides and potassium thiosulphate and containing an amount of sulphides corresponding to not less than 12.8 per cent. of sulphur (S). Preserve it in well-closed containers.

Summarized Description.

Irregular pieces; liver-brown, greenish-yellow or gray according to age; unstable; odor of hydrogen sulphide; soluble in water. For details see U.S.P., p. 330.

For *tests for identity*, and for *assay* see U.S.P. and also Part V of this book.

Remarks.—This product is made by heating together potassium carbonate and sublimed sulphur in a covered crucible until the mass is in a state of perfect fusion.

According to the proportional quantities of the ingredients, and also the amount of heat employed, any of the following reactions may occur:

$$\text{I. } 3K_2CO_3 + 6S_2 = 2K_2S_5 + K_2S_2O_3 + 3CO_2.$$
$$\text{II. } 3K_2CO_3 + 4S_2 = 2K_2S_3 + K_2S_2O_3 + 3CO_2$$
$$\text{III. } 4K_2CO_3 + 5S_2 = 3K_2S_3 + K_2SO_4 + 4CO_2.$$

This shows that sulphurated potassa is not a definite chemical, but a mixture of the polysulphides, the sulphate, and the thiosulphate of potassium.

Sulphurated potassa, when freshly prepared, is in the form of irregular pieces, of a liver-brown color, and from the last fact it has been given the synonym *liver of sulphur.* On exposure to air, however, it absorbs moisture, oxygen, and carbon dioxide, changes to greenish yellow, and eventually to a gray mass, the latter consisting of potassium carbonate, thiosulphate, and sulphate. It is needless to say that only the liver-colored preparation should be dispensed, and this necessity renders the preparation ineligible. The manufacture of it by the retail pharmacist is a matter of considerable difficulty and uncertainty, and yet if purchased in pound lots from the manufacturer, it becomes useless, or almost so, before a quarter has been used; moreover, there is no satisfactory method of preserving it.

Sulphurated potassa is sometimes used under the name of potassium sulphide as a laxative, in 5-grain doses.

POTASSII ACETAS—Potassium Acetate

(Pot. Acet.)

It contains, when dried to constant weight at 150°C., not less than 99 per cent. of $KC_2H_3O_2$ (98.12). Preserve it in air-tight containers.

Summarized Description.

White powder or satiny crystalline masses; very deliquescent; soluble in 0.5 part of water and in about 2 parts of alcohol. For details see U.S.P., p. 331.

For *tests for identity*, for *impurities* (heavy metals, arsenic) and for *assay* see U.S.P., p. 331 and also Part V of this book.

Remarks.—This salt is made by the treatment of potassium bicarbonate with acetic acid, as shown in the following equation:

$$KHCO_3 + HC_2H_3O_2 = KC_2H_3O_2 + CO_2 + H_2O.$$

The potassium acetate remains in the solution, while the carbon dioxide escapes in gaseous form, with copious effervescence. The solution of potassium acetate is then evaporated to dryness on a water-bath and immediately bottled.

Potassium acetate appears in the form of granules, odorless, and having a warm, saline taste. It is an extremely deliquescent salt, hence must always be kept in dry containers which are well sealed. It is given as a refrigerant and mild laxative.

Dose.—1 gramme (15 grains).

Potassium arsenite, K_2HAsO_3 or $KAsO_2$, is official in the form of *Fowler's solution, liquor potassii arsenitis* (U.S.P.). This preparation will be discussed among the arsenic compounds.

POTASSII BICARBONAS—Potassium Bicarbonate

(Pot. Bicarb.)

It contains, when dried to constant weight in a desiccator over sulphuric acid. not less than 99 per cent. of $KHCO_3$ (100.11). Preserve it in well-closed containers,

Summarized Description.

Colorless monoclinic prisms or white granular powder; soluble in 2.8 parts of water; almost insoluble in alcohol. For details see U.S.P., p. 331.

For *tests for identity*, for impurities (excess of carbonate, heavy metals) and for *assay* see U.S.P., p. 331 and also Part V of this book.

Remarks.—This salt is made by exposing the carbonate to the action of carbonic acid gas.

In expressing the reaction by simple addition, it is easy to see why the product is called *bi*carbonate.

The reaction is:

Potassium carbonate	K_2CO_3
Plus carbonic acid	H_2CO_3
Equals	$K_2H_2(CO_3)_2$
or two molecules of potassium bicarbonate	$2KHCO_3$

This shows that the bicarbonate really does contain twice as much carbonic acid as does the normal carbonate, a fact that is true of all salts bearing the prefix "bi." Formerly this process was carried on, suspending the carbonate in sacks over the fermenting vats of a brewery, and the crude bicarbonate thus obtained was placed on the market under the name of *saleratus*. At present the demand for saleratus. is not large, and the carbonating is performed with carbon dioxide obtained from other sources, the resulting bicarbonate being purified by crystallization.

So many of our pharmaceutic chemicals depend upon water for their crystalline form that it is well to call attention to the fact that water is not essential in the formation of all crystals, potassium bicarbonate being an illustration of a chemical in well-defined crystals containing no water.

Potassium bicarbonate is an antacid. It is not often administered, its chief use being for the manufacture of other potassium compounds, as explained above. It might be noted that it is used as a carbonating agent in the manufacture of the solution of magnesium citrate.

Dose.—1 gramme (15 grains).

POTASSII BITARTRAS—Potassium Bitartrate

(Pot. Bitart.—Cream of Tartar)

It contains, when dried to constant weight at 100°C., not less than 99.5 per cent. of $KHC_4H_4O_6$ (188.14). Preserve it in well-closed containers.

Summarized Description.

Colorless opaque, rhombic prisms or white powder; odorless; acidulous taste; soluble in 155 parts of water and in about 7100 parts of alcohol. For details see U.S.P., p. 332.

For *tests for identity*, for *impurities* (starch, kaolin, and calcium phosphate; heavy metals, ammonia, alum and lead) and for *assay* see U.S.P., p. 332 and also Part V of this book.

Remarks.—Potassium bitartrate (or *cream of tartar*) is the acid salt of tartaric acid $H_2C_4H_4O_6$, as explained on p. 362. It occurs in the form of a white, gritty powder and is also seen in the form of small rhombic crystals, although this form is comparatively rare. Its manufacture from argols will be discussed under tartaric acid. It is the one official potassium compound which is sparingly soluble in water, one part requiring 200 parts of water at 25°C. to dissolve it. The sparing solubility of cream of tartar is utilized in the manufacture of hydrobromic and other acids by the precipitation process. (See p. 393.) The fact just stated, however, that it does sparingly dissolve in water, shows us that hydrobromic acid made by the Fothergill process will be contaminated with bitartrate.

Cream of tartar is one of the most popular refrigerants and laxatives, being esteemed for sluggishness of the blood occurring during the spring and summer in warm climates. In such cases it is frequently administered in the form of lemonade, being combined with sugar and water, and possibly tamarinds, and the mixture taken in doses ranging from a wineglass to a cupful. Cream of tartar is a constituent of compound jalap powder.

Dose.—As diuretic, 2 grammes (30 grains).

POTASSII BROMIDUM—Potassium Bromide

(Pot. Brom.)

It contains, when dried to constant weight at 100°C., not less than 98.5 per cent. of KBr (119.02). Preserve it in well-closed containers.

Summarized Description.

Colorless, cubical crystals or white granular powder; odorless; saline taste; soluble in 1.5 parts of water and about 200 parts of alcohol. For details see U.S.P., p. 333.

For *tests for identity*, for *impurities* (bromate, iodides, heavy metals, sulphates, barium, excess of alkali, and for *assay* see U.S.P., p. 334, and also Part V of this book.

Remarks.—This valuable salt is prepared in two ways: The first process is the formation of ferrous bromide from iron and bromine, and the decomposition of this ferrous bromide by treatment with potassium carbonate, the two reactions being as follows:

$$\text{I.}\quad \underset{\text{Iron.}}{Fe} + \underset{\text{Bromine.}}{Br_2} = \underset{\text{Ferrous bromide.}}{FeBr_2}$$

$$\text{II.}\quad \underset{\substack{\text{Ferrous}\\ \text{bromide.}}}{FeBr_2} + \underset{\substack{\text{Potassium}\\ \text{carbonate.}}}{K_2CO_3} = \underset{\substack{\text{Ferrous}\\ \text{carbonate.}}}{FeCO_3} + \underset{\substack{\text{Potassium}\\ \text{bromide.}}}{2KBr}$$

The double decomposition between ferrous bromide and potassium carbonate works admirable, as the insoluble ferrous carbonate precipitates, leaving only potassium bromide in solution. This is filtered and the bromide crystallized out.

The second process is a little more complicated, but highly instructive. In the first stage, potassium hydroxide is treated with bromine, thus:

$$6KOH + 6Br = 5KBr + KBrO_3 + 3H_2O.$$

We get potassium bromide, KBr, contaminated with potassium bromate, $KBrO_3$, which is a salt of bromic acid, $HBrO_3$, which is derived from bromic oxide, Br_2O_5, in which compound bromide shows the valence v.

Bromic oxid........................	Br_2O_5
Plus water..........................	$H_2\ O$
Equals..........................	$H_2Br_2O_6$
or two molecules of bromic acid.......	$2H\ Br\ O_3$

This bromate is an undesirable addition to the bromide, and must be converted into the latter. If we compare the formula of the bromide, KBr, with that of the bromate, $KBrO_3$, we find the latter differs from the former only by having oxygen. This oxygen must be removed, and this is accomplished by the process of reduction, the reducing agent employed being carbon or charcoal, just as in the manufacture of sulphurous acid, the reaction being as follows:

$$KBrO_3 + C_3 = KBr + 3CO.$$

Potassium bromide is used as a sedative and nervine, and is frequently administered in combination with chloral.

Dose.—1 gramme (15 grains).

Sal Potassii Bromidi Effervescens (N.F.) contains 16.6 per cent. of potassium bromide, combined with sodium bicarbonate and with citric and tartaric acids and made into an effervescent salt.

Sal Potassii Bromidi Effervescens Compositus (N.F.) is a similar effervescent salt containing 8.3 per cent. of potassium bromide combined with caffeine (0.8 per cent.) lithium carbonate, sodium bicarbonate, citric and tartaric acids.

POTASSII CARBONAS—Potassium Carbonate

(Pot. Carb.—Salt of Tartar)

It contains, when dried to constant weight at 180°C., not less than 99 per cent. of K_2CO_3 (138.20). It contains not more than 15 per cent. of moisture. Preserve it in air-tight containers.

Summarized Description.—

White granular deliquescent powder; soluble in 0.9 part of water; insoluble in alcohol. For details see U.S.P., p. 334.

For *tests for identity*, for *impurities* (earthy matter, heavy metals) and for *assay* see U.S.P., p. 334 and also Part V of this book.

Remarks.—Potassium carbonate is known by several synonyms, among others, *salt of tartar*. It is called this because it can be made by heating cream of tartar, the reaction being:

$$2KHC_4H_4O_6 + 5O_2 = K_2CO_3 + 7CO_2 + 5H_2O.$$

The other synonyms are *pearl-ash* and *salt of wormwood*, the latter name being derived from the fact that a variety of potassium carbonate, which was well esteemed some centuries ago, was made from the ashes of wormwood.

As already mentioned (p. 407), potassium carbonate is one of the chief sources of the element, and large quantities of the crude salt are obtained from suint and from ashes. At the same time, however, considerable is manufactured by the same process used in sodium carbonate, and this process will be considered under making sodium carbonate (p. 432).

Potassium carbonate is a white, granular powder; it is very deliquescent, and hence should, like potassium acetate, be kept in well-stoppered bottles. It is used as an antacid, although its action is rather too irritating for general use, sodium bicarbonate being preferred. Taken in large quantities it has caustic action, and as an antidote, a mild acid should be used.

Dose.—1 gramme (15 grains).

Potassium carbonate is used considerably in some sections as an alkaline hair-wash, the object being to prevent blond hair from turning dark.

For this purpose it is of little value, and is, moreover, decidedly detrimental to the health of the hair.

POTASSII CHLORAS—Potassium Chlorate

(Pot. Chloras)

It contains not less than 99 per cent. of $KClO_3$ (122.56). Preserve it in well-closed containers. *Great caution should be observed in handling it,* as dangerous explosions are liable to occur when it is heated or subjected to concussion or trituration with organic substances (cork, tannic acid, dust, sugar, etc.), or with sulphur, sulphides, hypophosphites or other easily oxidizable substances.

Summarized Description.

Colorless monoclinic prisms or plates or white granular powder; soluble in about 16 parts of water (see below); insoluble in alcohol. For details see U.S.P., p. 335.

For *tests for identity,* for *impurities* (heavy metals) and for *assay* see U.S.P., p. 335 and also Part V of this book.

Remarks.—The formula of potassium chlorate is $KClO_3$, from chloric acid, $HClO_3$, from chloric oxide, Cl_2O_5, the graphic formula which was given on p. 351.

The formula of potassium chlorate, $KClO_3$, is analogous to $KBrO_3$, potassium bromate, and the chlorate can be made by passing chlorine into potassium hydroxide by a reaction similar to that occurring in the manufacture of potassium bromide:

$$6KOH + 6Cl = 5KCl + KClO_3 + 3H_2O.$$

But by this method, from six molecules of potassium hydroxide only one molecule of potassium chlorate is obtained, the remaining five atoms of potassium going to waste as potassium chloride, and a better method of manufacture is from chlorinated lime. This body, on being boiled with water, decomposes into calcium chloride and calcium chlorate by the following reaction:

$$3Ca(OCl)_2 + \text{heat} = Ca(ClO_3)_2 + 2CaCl_2.$$

The calcium chlorate solution is then treated with potassium chloride, when the following reaction occurs:

$$Ca(ClO_3)_2 + 2KCl = CaCl_2 + 2KClO_3.$$

The resulting calcium chloride is very soluble in water, and remains in solution, while the sparingly soluble potassium chlorate crystallizes out.

Potassium chlorate is now largely made by electrolysis.

The solubility of potassium chlorate is worth more than passing notice. The present pharmacopœia states that 1 gramme will dissolve in 11.5 mils of water at 25°C.; U.S.P. VIII stated that the salt was soluble in 16 parts of water at 25°C.; while U.S.P. 1890 stated that it was soluble in 16.7 parts of water at 15°C. It is the custom of many drug-stores to keep on hand a stock solution of potassium chlorate which is labeled a half-drachm to the fluidounce. If by half-drachm 30 grains is intended, such a solution is impossible at ordinary temperatures, inasmuch as only 27 grains of the salt will dissolve in an ounce of cold water. Nor is it wise for the operator to try to coax the remaining potassium chlorate to go into solution by warming the mixture. A solution will ensue, but on cooling the excess will surely separate out. Physicians, not aware of the exact solubility, sometimes prescribe 30 grains of potassium chlorate to the ounce of solution, and intend same for gargle. If this prescription is dispensed with the excess of the salt remaining in the mixture, the undissolved salt will act as irritant to the inflamed mucous membrane which it is intended to relieve. Hence the careful pharmacist always dispenses a clear, filtered solution of potassium chlorate when intended for gargle.

Potassium chlorate is a powerful oxidizing agent, and for this reason combines with many easily oxidizable substances, such as sulphur, antimony sulphide, phosphorus, starch, sugar, so energetically as to produce explosions; hence the pharmacopœial warning that this salt should not be triturated with any of the above substances. When called upon to mix such substances as potassium chlorate and sugar, they should first be powdered separately and then mixed together with a bone spatula on a piece of paper.

Potassium chlorate is a mild antiseptic, this property being due to its oxidizing action. Its chief application for this purpose is in cases of sore throat, for which it is much esteemed. Its indiscriminate use, however, for this purpose, especially in the form of lozenges and compressed tablets, is not advisable, for investigation shows that it has an irritating action on the bladder, and therefore should not be swallowed in large quantities. It is now being used in tooth pastes.

Dose.—250 milligrammes (4 grains).

POTASSII CITRAS—Potassium Citrate

(Pot. Cit.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of crystallized $K_3C_6H_5O_7+H_2O$ (324.36). Preserve it in well-closed containers.

Summarized Description.

Transparent prismatic crystals or white granular powder; somewhat deliquescent; Soluble in 0.6 part of water; almost insoluble in alcohol. For details see U.S.P., p. 336.

For *tests for identity*, for *impurities* (heavy metals, arsenic acid, tartrate) and for *assay* see U.S.P., p. 336 and also Part V of this book.

Remarks.—This salt is made by treatment of potassium bicarbonate with citric acid, as shown in the following equation:

$$3KHCO_3 + H_3C_6H_5O_7 = K_3C_6H_5O_7 + 3CO_2 + 3H_2O.$$

As mentioned above, the bicarbonate is used in preference to the carbonates in the manufacture of most of the potassium salts, and in this case the bicarbonate is absolutely necessary, the citrate made from the carbonate being quite unsatisfactory.

The potassium citrate occurs in transparent prismatic crystals or in white granular powder, both forms being rather deliquescent. It is used as a refrigerant.

Dose.—1 gramme (15 grains).

POTASSII CITRAS EFFERVESCENS—Effervescent Potassium Citrate

(Pot. Cit. Eff.)

Condensed Recipe.

Ingredients.—Potassium citrate, 200 Gm.; sodium bicarbonate, 477 Gm.; tartaric acid, 252 Gm.; uneffloresced citric acid, 162 Gm.

Manipulation.—After drying the citrate on a water-bath mix it with the acids and then with the bicarbonate. Granulate the mixture by heating to between 93° and 104°C. on glass plates in an oven and when soft, rub the mass through coarse No. 6 sieve. Then dry and seal in tight containers. For details see U.S.P., p. 336.

Remarks.—The granular effervescent salts have been considered on p. 152, so here it suffices to say that this preparation is supposed to contain acids and the potassium bicarbonate in uncombined form, but that when mixed with water, these two chemicals combine, with liberation of carbon dioxide gas and copious effervescence, making the mixture more palatable.

Dose.—4 grammes (60 grains).

LIQUOR POTASSII CITRATIS—Solution of Potassium Citrate

(Liq. Pot. Cit.)

An aqueous solution containing not less than 8 per cent. of $K_3C_6H_5O_7$ (306.34), with small amounts of citric and carbonic acids.

Condensed Recipe.

Dissolve 8 Gm. potassium bicarbonate in 40 mils of distilled water, filter and wash filter with enough water to make 50 mils. Likewise dissolve 6 Gm. citric acid in enough water to make 50 mils. In dispensing mix the two solutions and bottle.

Summarized Description.

Clear, colorless liquid; odorless; mildly saline taste. For details see U.S.P., p. 252.

For *tests for identity*, for *impurities*, see potassium citrate. For *assay* see U.S.P., p. 252 and also Part V of this book.

Remarks.—This preparation is made by dissolving separate solutions of potassium bicarbonate and citric acid, the quantity of the chemicals in each being so adjusted that when equal volumes of the two solutions are mixed, slightly acidulated potassium citrate will result. It is assumed that the pharmacist will not blend the two solutions until an order for the finished solution is received, and in this way the solution will be dispensed with sufficient effervescence remaining to make the liquid more palatable. The exact amount of "sparkle" is a matter of pharmaceutic judgment, for if the mixed liquid is quickly poured into a bottle and is tightly corked, there is danger of sufficient gas being evolved to cause an explosion of the flask in the hands of the purchaser.

The pharmacopœia of 1890 gave as a synonym of this solution *mistura potassii citratis*, because this preparation is intended to replace the mixture of potassium citrate (*neutral mixture*) of the pharmacopœia of 1880. The product of 1880 was much more palatable than the present official solution, because instead of citric acid, fresh lemon-juice was employed.

Potassium citrate is a mild refrigerant, and when dispensed in the effervescent form, constitutes a refreshing draft for fever patients.

A modification of the preparation quite popular in French countries is *potion de Rivière*. The French Codex directs that this be made by preparing two solutions, one consisting of citric acid, 2 parts; water, 50 parts; syrup of lemon, 15 parts; the other consisting of sodium bicarbonate, 2 parts; water, 50 parts; syrup, 15 parts; dispensing the two solutions in separate bottles, with directions to patient to mix equal parts and drink while effervescing. A similar recipe is found in the National Formulary. (See p. 192.) The original potion de Riviere was a solution of potassium citrate.

Dose.—Of official solution: 15 mils (4 fluidrachms).

Potassii Cyanidum (U.S.P.VIII), or *potassium cyanide* is made by heating potassium ferrocyanide with potassium carbonate in a red-hot crucible, when the following reaction ensues:

$$K_4Fe(Cn)_6 + K_2CO_3 = 5KCN + KOCN + CO_2 + Fe.$$

It will be seen from this reaction that the product will be contaminated with potassium cyanate, KOCN (p. 674). If a perfectly pure product is desired, it is made by passing hydrocyanic acid gas into an alcoholic solution of potassium hydroxide.

Potassium cyanide is now being made by an electric process. The demand for this chemical has greatly increased in late years, it being very largely used in metallurgic processes, the extraction of gold and silver from ores, etc.

Potassium cyanide occurs in white, irregular lumps, or as a white, granular powder, usually exhaling the odor of hydrocyanic acid, though odorless when perfectly dry. It is rather deliquescent, and therefore should be kept in well-stoppered bottles.

Great care should be taken in handling potassium cyanide, since it is a deadly poison.

When boiled with water, potassium cyanide splits up into potassium formate (p. 586) and ammonia, as shown in the following equation:

$$KCN + 2H_2O = KCHO_2 + NH_3.$$

For this reason solutions of the cyanide should never be heated.

In medicine, potassium cyanide affords a convenient way of obtaining the medicinal action of hydrocyanic acid, and a prescription calling for potassium cyanide and citric acid was formerly considerably used.

Dose.—10 milligrammes (1/6 grain).

Potassii Dichromas (U.S.P. VIII) or *potassium dichromate*, is an interesting chemical inasmuch as it contains no hydrogen whatever, and in this case the rule laid down, that an acid salt is one in which all the hydrogen of the acid is not replaced by a metal, fails utterly. It is just such exceptions and variations in the nomenclature of chemistry that make its study difficult.

Let us dissect this compound, potassium dichromate, $K_2Cr_2O_7$. Its sister compound is potassium chromate, K_2CrO_4, which is derived from chromic acid, H_2CrO_4, which comes from chromic oxide, CrO_3, a body analogous to SO_3.

Potassium chromate..................	K_2CrO_4
Plus chromic oxide..................	CrO_3
Gives potassium dichromate..........	$K_2Cr_2O_7$

This compound is made from chromic iron ore, a mineral formerly mined in considerable quantities in Pennsylvania and Maryland, but now practically all imported from Europe. This ore is roasted with potassium carbonate and lime in presence of air, when the potassium chromate is formed by the following reaction:

$$2FeOCr_2O_3 + CaO + 3K_2CO_3 + 7O \text{ (from air)} = 3K_2CrO_4 + CaCrO_4 + Fe_2O_3 + 3CO_2.$$

This potassium chromate is then converted into potassium dichromate by treatment with sulphuric acid, as shown in the following equation:

$$2K_2CrO_4 + H_2SO_4 = K_2Cr_2O_7 + K_2SO_4 + H_2O.$$

The calcium chromate of the first reaction is treated with potassium sulphate, and is thus converted into potassium chromate, which is changed to dichromate by use of sulphuric acid.

Dichromate of potassium occurs in orange-yellow crystals, which are soluble in 9 parts of water and in 1½ parts of boiling water. Its chief use in pharmacy is as an oxidizing agent, for when treated with sulphuric acid it splits into chromic acid, one of the best oxidizing agents. It will be recalled that the oxidizing action of the dichromate mixture was suggested as a way of cleaning mortars. (See p. 115.) The dichromate mixture is also used as a battery fluid. It is rarely used in medicine; if so, it is employed as a remedy in syphilis.

If an excessive dose is taken, the antidote would be a mild alkali, such as soap, magnesia, or chalk.

Dose.—10 milligrammes (1/5 grain).

POTASSII ET SODII TARTRAS—Potassium and Sodium Tartrate

(Pot. et Sod. Tart.—Rochelle Salt)

It contains not less than 73.72 per cent. nor more than 77.39 per cent. of anhydrous potassium and sodium tartrate, corresponding to not less than 99 per cent. of the crystallized salt [$KNaC_4H_4O_6 + 4H_2O = 282.20$]. Preserve it in well-closed containers.

Summarized Description.

Colorless rhombic prisms or white powder; somewhat efflorescent; soluble in 0.9 mil of water; almost insoluble in alcohol. For details see U.S.P., p. 337.

For *tests for identity*, for *impurities* (heavy metals, ammonia, lead) and for *assay* see U.S.P., p. 337 and also Part V of this book.

Remarks.—This compound is interesting as one of the two official double salts of tartaric acid, the other being tartar emetic. (See p. 530.) It is made by treating potassium bitartrate with sodium bicarbonate, when the following reaction will occur:

$$KHC_4H_4O_6 + NaHCO_3 = KNaC_4H_4O_6 + CO_2 + H_2O.$$

The chemistry of this body can be discussed when the composition of the acid from which it is derived is noticed; hence it is reserved until later (p. 604).

Sodium and potassium tartrate (*Rochelle salt, sal Seignette* or *sal polychresticum*) is used as a mild laxative and refrigerant. It is one of the constituents of official Seidlitz powder.

Dose.—10 grammes (2½ drachms).

Potassii Ferrocyanidum (U.S.P. VIII) $K_4Fe(CN)_6 + 3H_2O$ is interesting as the source of cyanides. It is made from a mixture of nitrogenous animal matter, pearl-ash (potassium carbonate), and scrap-iron, all being heated together in an iron pot.

Details of the manufacture of this substance will be studied when we consider the cyanogen preparations. (See p. 674.)

Potassium ferrocyanide is rarely used in medicine. When pure, it is not poisonous despite the presence of the cyanogen group. A solution of potassium ferrocyanide, we will find later, is used in testing iron (p. 501).

Dose.—500 milligrammes (7½ grains).

Under this head mention might be made of *potassium ferricyanide*, $K_3Fe(CN)_6$, which is used in testing for iron in the ferrous form (p. 501). The chemistry of both of these bodies is difficult and will be left to be discussed under the Cyanogen Compounds.

POTASSII HYPOPHOSPHIS—Potassium Hypophosphite

(Pot. Hypophos.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 98 per cent. of KPH_2O_2 (104.16). Preserve it in well-closed containers in a dry place. Caution should be observed in dispensing Potassium Hypophosphite, as an explosion is liable to occur when it is triturated or heated with nitrates, chlorates, or other oxidizing agents.

Summarized Description.

White opaque hexagonal plates, crystalline masses, or granular powder; very deliquescent; soluble in 0.6 part of water and in about 7.3 parts of alcohol. For details see U.S.P., p. 339.

For *tests for identity*, for *impurities* (phosphates, arsenic) and for *assay* see U.S.P., p. 339 and also Part V of this book.

Remarks.—This salt is made by treating calcium hypophosphite with potassium carbonate, as shown in the following equation:

$$Ca(PH_2O_2)_2 + K_2CO_3 = 2KPH_2O_2 + CaCO_3.$$

Solution of potassium hypophosphite is removed from the insoluble calcium carbonate by filtration. The solution is then evaporated on a water-bath with great care until a granular mass results. The caution as to evaporation is necessary in heating every hypophosphite, as even at the temperature of the water-bath there is danger of an explosion, due to the formation of the spontaneously combustible phosphine, PH_3.

Potassium hypophosphite, in common with all hypophosphites, is used largely as a tonic in wasting diseases, and is a constituent of the syrup hypophosphites (U.S.P.). It is now considered of little value therapeutically.

Dose.—500 milligrammes (8 grains).

POTASSII IODIDUM—Potassium Iodide

(Pot. Iod.)

It contains, when dried to constant weight at 100°C., not less than 99 per cent. of KI (166.02). Preserve it in well-closed containers.

Summarized Description.

Colorless or white cubic crystals or white granular powder; pungent, saline, bitter taste; soluble in 0.7 part of water and about 17 parts of alcohol. For details see U.S.P. p. 340.

For *tests for identity*, for *impurities* (iodate, heavy metals, barium, cyanide, thiosulphate, alkali) and for *assay* see U.S.P., p. 341 and also Part V of this book.

The manufacture of this important chemical is similar to that of potassium bromide, only the first process is by treatment of ferric iodide with potassium bicarbonate or carbonate. This is somewhat different from the ferrous bromide reaction in making potassium bromide. As in the bromide process, iron is treated with the halogen element, making the ferrous iodide solution; however, more iodine is added, making the more stable ferric iodide, FeI_3, and when this is treated with potassium carbonate, the following reaction occurs:

$$2FeI_3 + 3K_2CO_3 + 3H_2O = 6KI + 3CO_2 + 2Fe(OH)_3.$$

The second process is by treating solution of potassa with iodine, and is closely similar to that for making potassium bromide:

$$6KOH + 6I = 5KI + KIO_3 + 3H_2O.$$

As in the bromide process, the iodate is reduced to iodide by heating with charcoal, viz.:

$$KIO_3 + C_3 = KI + 3CO.$$

Potassium iodide occurs in colorless, translucent, cubic crystals, having a faint iodine odor, and a saline, afterward bitter, taste. It is exceedingly soluble in water (1 part to 0.7 at 25°C.), which renders possible the preparation of the saturated solution of potassium iodide, containing 456 grains of chemical in a fluidounce of the finished solution. (See p. 425.)

As mentioned above, the crystals of potassium iodide should be either transparent or else translucent. The larger majority of the commercial iodide is in white, opaque crystals. These are impure, being crystallized from an alkaline medium. It is but fair to the manufacturer, however, to say that the preparation of a neutral potassium iodide is a matter of considerable difficulty, as there is danger of the separation of the iodine turning the crystals brownish.

Potassium iodide is a most valuable alterative. It is a constituent of *compound solution of iodine, tincture of iodine* and *ointment of iodine.*

Dose.—300 milligrammes (5 grains).

POTASSII NITRAS—Potassium Nitrate

(Pot. Nitras —Saltpetre)

It contains, when dried to constant weight at 100°C., not less than 99 per cent. of KNO_3 (101.11). Preserve it in well-closed containers.

Summarized Description.

Colorless rhombic prisms or white crystalline powder; saline and cooling taste; slightly deliquescent, soluble in about 2.8 parts of water and about 500 parts of alcohol. For details see U.S.P., p. 341.

For *tests for identity,* for *impurities* (heavy metals, chlorate, perchlorate) see U.S.P., p. 341.

Remarks.—This chemical, commonly called *saltpetre,* has been in popular use for centuries. The original method of manufacture was interesting; being made by the treatment of ashes with decaying nitrogenous matter, such as manure and cattle urine. The mass was allowed to stand under roughly constructed sheds for several months, being occasionally turned so as to present new surfaces to the air. When the fermentation of the mass is completed, it is placed in crude percolators and lixiviated with water, whereby the finished potassium nitrate is separated from the extraneous matter.

Repeated crystallization of this solution eventually results in a pure crystalline nitrate.

Investigations of the manufacture of saltpeter on these "saltpetre plantations" has shown that the change of the nitrogenous matter to the nitrate is a species of fermentation, being produced by a peculiar microscopic plant called *nitromonas.* This process of saltpetre manufacture was formerly largely used, as it yielded not only all the saltpetre used, but also because this potassium nitrate was the source of nitric acid and all the nitrates.

At present, however, the source of nitric acid is Chile saltpetre (see p. 378), from which potassium nitrate is made, as shown in the following equation:

$$NaNO_3 + KCl = KNO_3 + NaCl$$

the resulting salts being separated by fractional crystallization. It is also made from synthetic sodium nitrate by a similar process. (See p. 438.)

One of the largest general uses of potassium nitrate is in the manufacture of *gunpowder,* of which the average formula is potassium nitrate, 75 parts; powdered charcoal, 15 parts; and sulphur, 10 parts, the mass being mixed together, then granulated by wetting the mass, passing it through a sieve, and carefully drying the resulting granules. Gunpowder explodes by the following reaction:

$$2KNO_3 + S + 3C = K_2S + 3CO_2 + N_2.$$

On examination of the above equation it will be seen that the chemical action between the three solids results in the formation of two gases and a comparatively small amount of the solid potassium sulphide. One volume of gunpowder gives 280 volumes of mixed gases, and on this property hinges the whole theory of explosion, which means the sudden evolution of a large volume of gas from a comparatively small quantity of the solid or liquid.

In the potassium sulphide of the above reaction is found an explanation of the peculiar odor of a burned fire-cracker.

In medicine, potassium nitrate is used largely as a diuretic.

Dose.—500 milligrammes (8 grains).

Potassium nitrate acts as an oxidizing agent in the explosion of gunpowder, and to this oxidizing action is due the value of potassium nitrate as an antiseptic. Its use as a preservative of meat and other foods is too well known to require extended comment here.

POTASSII PERMANGANAS—Potassium Permanganate

(Pot. Permang.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of $KMnO_4$ (158.03). Preserve it in glass-stoppered bottles. Potassium Permanganate when in solution or in the dry condition must not be brought into contact with organic or other readily oxidizable substances.

Summarized Description.

Slender, dark purple, monoclinic prisms; sweet, then disagreeable astringent taste; soluble in 13.5 parts of water; decomposed by alcohol; dissociates on heating into oxygen, potassium manganate and manganese dioxide. For details see U.S.P., p. 342.

For *tests for identity* and for *assay* see U.S.P., p. 342 and also Part V of this book.

Remarks.—Potassium permanganate is now given the formula $KMnO_4$, in preference to that of the pharmacopœia of 1880, $K_2Mn_2O_8$. It represents the highest known valence of manganese—the valence VII —and is an analogue of potassium perchlorate, $KClO_4$, which comes from perchloric oxide, Cl_2O_7, the graphic formula of which was given on p. 351. The permanganate is one of the oxidizing agents, the action of which is explained on p. 403.

It is made by treatment of manganese dioxide with potassium hydroxide and potassium chlorate, this mixture yielding potassium manganate, as shown in the following equation:

$$3MnO_2 + 6KOH + KClO_3 = 3K_2MnO_4 + KCl + 3H_2O.$$

It will be observed that potassium manganate (K_2MnO_4) has a formula similar to that of potassium sulphate, in this body the manganese acting with the valence VI. When this green potassium manganate is boiled with water, it is converted into the purple potassium permanganate, as shown in the following equation:

$$3K_2MnO_4 + 3H_2O = 2KMnO_4 + MnO_2 + 4KOH + H_2O.$$

In modern technic, this last reaction is performed by electrolysis.

The process occurs in miniature in an important test for manganese, which consists of fusing the three constituents above given on a piece of platinum foil and then boiling in water. If the fused mass is green and the resulting liquid is pink, it indicates the presence of manganese.

By reason of this change of tint, potassium permanganate has been given the synonym of *mineral chameleon.*

It will be noticed that the products of the final reaction consist of some binoxide of manganese and also potassium hydroxide, and in order to secure the permanganate from this mixture, it is necessary to neutralize the excess of potassium hydroxide with sulphuric acid. The solution of permanganate is then filtered through asbestos to remove the precipitated manganese dioxide, and the filtrate concentrated until crystallization begins.

Potassium permanganate occurs in purple, monoclinic crystals, which possess a blue, metallic luster in reflected light. It is soluble in 13.5 parts of water and forms a purple-red solution. The pharmacopœia gives a warning that it should never be triturated with easily oxidizable substances, while pills of potassium permanganate should not be made with ordinary excipients, but with petroleum mass (petrolatum and kaolin).

The oxidizing action of potassium permanganate in neutral solution is best shown by the following equation:

$$2KMnO_4 + H_2O = 2MnO_2 + 2KOH + O_3.$$

This, when reduced to words, means that two molecules of the permanganate yield three atoms of available oxygen. By comparison of this with the oxidizing equation of nitric acid, given on p. 399, it is seen that the process of the two cases is similar.

When permanganate acts in acid solution, two molecules (or one molecule of $K_2Mn_2O_8$ if that is accepted as the formula) liberate five atoms of oxygen, as shown in the following equation:

$$2KMnO_4 + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 3H_2O + O_5.$$

This is the basis of the use of potassium permanganate in volumetric analysis (Part V).

Potassium permanganate is one of the most convenient oxidizing agents for use in organic chemistry. As already stated, nitric acid is the oxidizing agent generally used in the ordinary processes of oxidation we meet in pharmacy. The acid, however, acts too violently for use in many organic oxidations, and for such purposes either potassium permanganate or chromic acid is employed. The only pharmaceutic application of this use of permanganate is in purifying alcoholic distillates. In such cases it is well to note that the permanganate decomposes with the formation of not only insoluble manganese dioxide, but also potassium hydroxide, which will go into solution. Therefore, before such purified alcohol can be employed, it should be redistilled.

Potassium permanganate is a valuable antiseptic in medicine, and is largely used in surgical practice. One advantage it possesses over the ordinary oxidizing antiseptics is its comparative freedom from caustic action. In practice it is frequently prescribed in the form of *Condy's fluid*, which consists of 128 grains permanganate to one pint of distilled water. It is now largely used internally in a solution 1 to 1000 as an antidote for organic poisons.

Dose.—65 milligrammes (1 grain), preferably in a fine powder in capsules.

Potassii Sulphas (U.S.P. VIII; N.F. IV) or *potassium sulphate*, K_2SO_4, is made from the ore, *kainite*, which has the composition $K_2SO_4MgSO_4MgCl_25H_2O$. It is also produced by treating either potassium nitrate or potassium chloride with sulphuric acid. It is in the form of colorless, transparent, rhombic crystals, soluble in 9½ parts of water. It is interesting to note that these crystals contain no water of crystallization, thereby differing from the otherwise similar sodium sulphate, which contains ten molecules of water of crystallization.

Potassium sulphate is employed as a diuretic and refrigerant. Its use is rather limited, especially as the pharmacopœia has omitted its use in the manufacture of Dover's powder. The original recipe for this pharmaceutic directed that the ipecac and opium be triturated with crystallized potassium sulphate; but in the present pharmacopœia sugar of milk is substituted for this salt. (See p. 293.)

Dose.—1 gramme (15 grains).

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CHAPTER XXVI

SODIUM

Symbol, Na. Atomic weight, approximately 23.

The symbol Na is an abbreviation of the words *natrium*, this being derived from natron, which was from the Greek word *nitron*, which was the original name of the carbonate. Our English word sodium is derived from soda, which comes from the word *sodash*, this hinting its preparation from the ashes of "sods," or marine plants.

Sodium, like potassium, was isolated by Sir Humphrey Davy in 1807 by the electrolysis of the hydroxide. (See p. 408.)

Occurrence.—The most abundant source of sodium is common salt, or sodium chloride, this being a constituent of sea-water, but chiefly obtained in commerce either from mines or by the evaporation of brine from salt-wells. Sea-water is a scarcely available source of sodium chloride, because therein are found chlorides of many other elements which are separated with difficulty.

Manufacture.—The element sodium is isolated by a process quite similar to that by which we obtain potassium, viz., by heating carbonate with coal, chalk being added as a flux. This process is not so dangerous as is the preparation of potassium, inasmuch as the sodium carbonyl, NaCO, does not solidify in the delivery tube. (See p. 408.)

Metallic sodium is now being made by treating sodium hydroxide with iron carbide at a temperature of 1000°C.

It is also obtained by the electrolysis of sodium hydroxide in the same manner employed in isolating potassium.

Properties.—Sodium is a soft, silvery-white metal, resembling potassium, and, like it, is so easily oxidized that it must be kept under petroleum. When metallic sodium and mercury are rubbed together, an amalgam results which, when brought into contact with moisture, ignites. This mixture has been used as a cigar-lighter, but its danger was such that it never became popular.

The characteristic tests of the element and its salts are the yellow color that it communicates to a colorless flame; a white precipitate formed when a solution of sodium salt is brought into contact with a solution of pyroantimoniate of potassium.

The sodium flame is counted among the most delicate of tests, it having been estimated that $\frac{1}{65,000,000}$ grain will respond thereto. By reason of its sensitiveness the positive testing of sodium with the flame is difficult, as almost anything tested will give a yellow flame by reason of the presence of minute traces of sodium. Hence the chemist trains his eye to a rough estimation of the quantity shown by the intensity of the flame, rather than by the bare fact of the presence of a yellow color.

The following compounds of sodium and their preparations are official:

Sodium hydroxide	90	per cent.	absolute.	NaOH.
Solution of sodium hydroxide	4.5	"	"	NaOH.
Sodium acetate	99.5	"	"	$NaC_2H_3O_2+3H_2O$.
Sodium benzoate	99	"	"	$NaC_7H_5O_2$.
Sodium bicarbonate	99	"	"	$NaHCO_3$.
Lozenges of sodium bicarbonate	(pharmaceutic).			
Sodium borate	99	"	"	$Na_2B_4O_7+10H_2O$.
Sodium bromide	98.5	"	"	NaBr.
Monohydrated sodium carbonate	99.5	"	"	$Na_2CO_3+H_2O$.
Sodium chloride	99	"	"	NaCl.

Physiological solution of sodium chloride contains 8.5 Gm. sodium chloride to the liter.

Sodium citrate	98	per cent.	absolute.	$Na_3C_6H_5O_7+2H_2O$.
Sodium cyanide	95	"	"	NaCN.
Sodium glycerophosphate	68	"	"	$Na_2C_3H_7PO_6$.
Sodium hypophosphite	98	"	"	$NaPH_2O_2+H_2O$.
Sodium iodide	99	"	"	NaI.
Sodium nitrite	95	"	"	$NaNO_2$.
Sodium perborate	86.5	"	absolute.	$NaBO_3+4H_2O$.
Sodium phenolsulphonate	99	"	"	$NaC_6H_5O_4S+2H_2O$.
Sodium phosphate	99	"	"	$Na_2HPO_4+12H_2O$.
Exsiccated sodium phosphate	98	"	"	Na_2HPO_4.
Effervescent sodium phosphate	20	per cent.	exsiccated	sodium phosphate.
Sodium salicylate	99.5	"	absolute.	$NaC_7H_5O_3$.
Sodium sulphate	99	"	"	$Na_2SO_4+10H_2O$.
Exsiccated sodium sulphite	90	"	"	Na_2SO_3.
Sodium thiosulphate	99	"	"	$Na_2S_2O_3+5H_2O$.

We might also add:

Potassium and sodium tartrate (considered among the potassium salts).
Solution of chlorinated soda (considered among the chlorine preparations).
Sodium arsenate (considered among the arsenic compounds).
Exsiccated sodium arsenate (considered among the arsenic compounds).
Solution of sodium arsenate (considered among the arsenic compounds).
Sodium benzosulphinide (considered among the benzoic acid derivatives).
Sodium cacodylate (considered among the arseno-organics).
Sodium indigotindisulphonate (considered among the indigo derivatives).

SODII HYDROXIDUM—Sodium Hydroxide

(Sod. Hydrox.—Caustic Soda—Sodium Hydrate)

It contains not less than 90 per cent. of NaOH (40.01). Preserve it in well-closed containers. If bottles are used as containers they must be made of hard glass.

Summarized Description.

Dry, white flakes, fused masses or brittle sticks; very caustic; deliquescent in air, absorbing both water and carbon dioxide; soluble in about 1 part of water and very soluble in alcohol. For details see U.S.P., p. 390.

For *tests for identity*, for *impurities* (organic matter, potassium, heavy metals) and for *assay* see U.S.P., p. 390 and also Part V of this book.

Remarks.—Soda is prepared by the evaporation of a solution of soda. It occurs in irregular lumps or in cylindric sticks, just as does potassa, and is, in fact, very similar to potassa, being decidedly caustic and possessing the same soapy taste, which is a distinguishing characteristic of the alkalis. It differs from potassa, however, in being less deliquescent.

Soda cum Calce (N.F.) is a mixture of equal quantities of sodium hydroxide and calcium oxide. It is sometimes called *London paste.*

LIQUOR SODII HYDROXIDI—Solution of Sodium Hydroxide

(Liq. Sod. Hydrox.—Liquor Sodæ—Solution of Soda)

An aqueous solution containing not less than 4.5 per cent. of NaOH (40.01). Preserve Solution of Sodium Hydroxide in bottles made of hard glass and provided with rubber stoppers or with glass stoppers coated with petrolatum.

Condensed Recipe.

Dissolve 56 Gm. sodium hydroxide in 944 Gm. distilled water. For details see U.S.P.

Summarized Description.

Clear, colorless liquid; caustic; strongly alkaline; absorbs carbon dioxide from the air; sp. gr. 1.056. For details see U.S.P., p. 255.

For *tests for identity*, for *impurities* see sodium hydroxide. For *assay* see U.S.P., p. 255 and also Part V of this book.

Remarks.—Solution of soda is an aqueous solution, containing 4.5 per cent. of absolute NaOH. It is prepared by a process analogous to that of the manufacture of the solution of potassa, by treatment of sodium carbonate with calcium hydroxide, as shown in the following equation:

$$Na_2CO_3 + Ca(OH)_2 = 2NaOH + CaCO_3.$$

Note that the words sodium and soda are not to be used indiscriminately. Sodium is an element, while soda is the hydroxide of that element. Note the absurdity and real danger of the term "soda-water," which is a solution of carbonic oxide in water.

The solution of soda is used as an antacid.

Dose.—1 mil (15 minims), very largely diluted.

Antidotes.—(See p. 411.)

SODII ACETAS—Sodium Acetate

(Sod. Acet.)

It contains not less than 59.97 per cent. nor more than 62.96 per cent. of anhydrous Sodium Acetate, corresponding to not less than 99.5 per cent. of the crystallized salt [$NaC_2H_3O_2+3H_2O=136.07$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, transparent, monoclinic prisms or granular powder; cooling saline taste; somewhat efflorescent; soluble in about 0.8 part of water and about 15 parts of alcohol. For details see U.S.P., p. 380.

For *tests for identity*, for *impurities* (potassium, arsenic, heavy metals) and for *assay* see U.S.P., p. 380 and also Part V of this book.

Remarks.—Sodium acetate, like the potassium salt, is made from acetic acid, and the "stock" salt of the metal. It will be remembered that the stock salt of potassium—the one usually employed in the manufacture of ordinary salts of that metal—was the bicarbonate, the carbonate being inadmissible by reason of its indefinite quality. With sodium compounds the "stock" salt is the carbonate, as it is readily crystalline and quite stable if kept in a well-corked bottle. Its tendency is toward efflorescence—not deliquescence—such is the usual inclination of sodium compounds; just as soda soap—Castile soap—grows hard and dry on standing: while potassa soap—soft soap—and other potassium compounds are usually deliquescent.

Sodium acetate is made by the action of acetic acid on sodium carbonate, and the latter salt is used in the manufacture of most sodium compounds. Let us compile a list of official sodium salts prepared from the carbonate:

Sodium benzoate from benzoic acid and sodium carbonate.
Sodium bromide from ferrous bromide and sodium carbonate.
Sodium hypophosphite from calcium hypophosphite and sodium carbonate.
Sodium iodide from ferrous iodide and sodium carbonate.
Sodium phosphate from acid calcium phosphate and sodium carbonate.
Sodium salicylate from salicylic acid and sodium carbonate.
Sodium sulphite from sulphurous acid and sodium carbonate.
Sodium sulphocarbolate from barium sulphocarbolate and sodium carbonate.
Solution of sodium silicate (U.S.P. 1890) from sand and sodium carbonate.
Sodium arsenate from arsenous acid, sodium nitrate, and sodium carbonate.

The pharmaceutic value of sodium carbonate can thus be seen.

Sodium acetate occurs in the form of colorless, transparent crystals, or in a granular powder, and must be kept in well-stoppered bottles since it is efflorescent in warm, dry air and is therefore likely to lose its water of hydration.

Dose.—1 gramme (15 grains).

SODII ARSENAS—Sodium Arsenate

SODII ARSENAS EXSICCATUS—Exsiccated Sodium Arsenate

These will be considered among the arsenic compounds (p. 526).

SODII BENZOAS—Sodium Benzoate

(Sod. Benz.)

It contains, when dried to constant weight at 110°C., not less than 99 per cent. of $NaC_7H_5O_2$ (144.04). Preserve it in well-closed containers.

Summarized Description.

White, amorphous, granular or crystalline powder; sweetish taste; soluble in about 1.8 parts of water and about 49 parts of alcohol. For details see U.S.P., p. 382.

For *tests for identity*, for *impurities* (heavy metals) and for *assay* see U.S.P., p. 382 and also Part V of this book.

Remarks.—This salt, the manufacture of which is outlined above, has come into prominence during the past decade, because of the controversy concerning its use as a preservative. *Dose.*—1 gramme (15 grains).

Sodium bicarbonate, $NaHCO_3$, will be considered along with sodium carbonate, as the two are so mutually dependent that they should be studied together.

Sodium Bisulphis (U.S.P. VIII) or *Sodium bisulphite* is another of the acid salts described on p. 362. Being a bisulphite, it is a derivative of sulphur*ous* acid, which itself is derived from sulphurous oxide. This oxide shows sulphur with the valence IV, and its formula is SO_2, as is shown graphically on p. 362. $SO_2+H_2O=H_2SO_3$, which is sulphurous acid. When all the hydrogen of sulphurous acid is replaced by sodium, we get sodium sulphite, Na_2SO_3, but when only one of the hydrogen atoms is replaced—by one atom of sodium—we get the bisulphite, $NaHSO_3$.

This salt is made by passing sulphurous acid gas through solution of sodium carbonate to saturation. The solution is then cooled, when the salt crystallizes out.

Sodium bisulphite is an unstable solid, rapidly losing sulphur dioxide and becoming oxidized to sulphate. For this reason it should be kept in a cool place, in small, well-stoppered bottles, which are to be completely filled. Sodium bisulphite is used as a reducing agent in organic chemistry, and is particularly valuable in the bleaching industry for the removing of the last traces of chlorine from the bleached fabric. Substances used for this purpose are known as *antichlors*. It is comparatively little used in medicine, but when so used, it is as an antiseptic.

Dose.—500 milligrammes (7½ grains).

SODII BORAS—Sodium Borate

(**Sod. Bor.**—Borax—Sodium Tetraborate—Sodium Pyroborate)

It contains not less than 52.32 per cent. nor more than 54.92 per cent. of anhydrous sodium borate (sodium biborate or tetraborate), corresponding to not less than 99 per cent. of the crystallized salt [$Na_2B_4O_7+10H_2O=382.16$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, monoclinic prisms or white powder; sweetish alkaline taste; slightly efflorescent; soluble in about 15 parts of water and in 1.25 parts of glycerin; insoluble in alcohol; on heating it melts, then forms a porous mass and then fuses to a glassy mass. For details see U.S.P., p. 384.

For *tests for identity*, for *impurities* (carbonates, bicarbonates, heavy metals, arsenic) and for *assay* see U.S.P., p. 384 and also Part V of this book.

Sodium borate—ordinary *borax*—is a valuable and interesting chemical. Its formula, $Na_2B_4O_7$, seems most difficult, and contradictory to the formula of boric acid already given—H_3BO_3, but investigation clears up the matter. Remember that the valence of boron is III; that boric acid is a true ortho-acid—$B(OH)_3$ or H_3BO_3. True sodium borate has the formula Na_3BO_3, and what we call sodium borate is not the true salt but a "*pyroborate.*" The Greek word for fire is "*pyros*," and all chemicals bearing the prefix "*pyro*" are bodies formed under influence of high heat. In passing, such examples as "pyroligneous acid" (crude acetic acid), "pyrogallic acid," and "pyrophosphoric acid" may be cited. Like these, pyroboric acid and pyroborates are made by subjecting the mother substance to heat.

Let us see what will occur when boric acid is heated. It will, of course, like all ortho-acids, lose water, and, under proper conditions, in a most peculiar ratio:

Taking $4H_3BO_3$, this carried out gives	$H_{12}B_4O_{12}$
Let us subtract from this $5H_2O$,	$H_{10}\quad O_5$
We then have left pyroboric acid,	$H_2\,B_4O_7$

the sodium salt of which, $Na_2B_4O_7$, is official borax, which is a natural product, being found in certain lakes of Thibet, Tartary, and India. The impure borax, obtained by spontaneous evaporation of the waters of these lakes, is called *tincal.* At the present time practically all the American borax is obtained from the borax lakes found in the Death Valley of Nevada. It is also made by treating the native boric acid of Tuscany with sodium carbonate.

Borax occurs either in colorless, transparent prisms or in a white powder, odorless, and having a sweetish, alkaline taste.

It is soluble in 15 parts of water and in 1 part of glycerin. When heated, it fuses and solidifies into a transparent solid called borax glass. This borax glass is used quite largely in analytic work under the name of borax bead, the chemical being fused on loop of platinum wire, thereby forming a minute globule of borax glass. When this body is melted with certain metallic salts, the body is given characteristic colors. (See p. 861.)

Borax is one of the most valuable of the sodium compounds. It is used in numerous operations where a mild alkali is indicated, it completely possessing the character of an alkali, and yet acts in a manner much milder than does either sodium carbonate or the bicarbonate. This explains its extensive use in cleaning delicate fabrics, such as fine cloth or hair, where stronger alkalis would act disastrously. It is also a valuable antiseptic, and for such purposes it is (improperly) used as a preservative for meats and food. In medicine it is used as a mild antiseptic, chiefly externally.

Dose.—750 milligrammes (12 grains).

Compound Solution of Sodium Borate (N.F.), or *Dobell's Solution*, is rather largely used as a nasal douche. (See p. 191.)

SODII PERBORAS—Sodium Perborate

(Sod. Perbor.)

It contains not less than 9 per cent. of available oxygen, corresponding to about 86.5 per cent. of $NaBO_3+4H_2O$ (154.06). Preserve it in well-closed containers, in a cool place.

Summarized Description.

White, crystalline granules or powder; saline taste; stable in dry air, but liberates oxygen in moist air; soluble in water; the solution decomposing into sodium metaborate and hydrogen dioxide. For details see U.S.P., p. 394.

For *tests for identity*, for *impurities* (heavy metals) and for *assay* see U.S.P., p. 394 and also Part V of this book.

Remarks.—This and other perborates have come into considerable use as solid substitutes for hydrogen dioxide. The sodium compound can be made by treating borax with sodium hydroxide and sodium dioxide. For dusting powder, where a dioxide is indicated the perborate is used, as sodium peroxide cannot be employed since strongly alkaline.

Sodium perborate is a white powder sparing soluble in water, but forming a stable solution having the action of hydrogen dioxide. When treated with diluted sulphuric acid, hydrogen dioxide is evolved.

It is now in considerable use as a non-irritating antiseptic.

Dose.—60 milligrammes (1 grain).

Sodii Boro-Benzoas (N.F.) is a mixture of sodium borate and sodium benzoate.

SODII BROMIDUM—Sodium Bromide

(Sod. Brom.)

It contains, when dried to constant weight at 100°C., not less than 98.5 per cent. of NaBr (102.92). Preserve it in well-closed containers.

Summarized Description.

Colorless cubical crystals or white granular powder; saline taste; somewhat hygroscopic; soluble in about 1.1 parts of water and in about 13 parts of alcohol. For details see U.S.P., p. 385.

For *tests for identity*, for *impurities* (alkali, iodides, heavy metals, bromates, sulphates, barium) and for *assay* see U.S.P., p. 385 and also Part V of this book.

Remarks.—This chemical is made by methods analogous to those employed in making potassium bromide; that is, by treatment of sodium hydroxide with bromine, and the subsequent heating of the mixture with charcoal, or by the double decomposition of ferrous bromide with sodium bicarbonate.

Sodium bromide occurs in white, cubic crystals which are soluble in 1.1 parts of water. While potassium bromide dissolving in water produces a chilled liquid, sodium bromide and water make a warm solution. Hemm claims that this is due to the hydration of sodium bromide in dissolving. The crystals attract moisture, but do not liquefy therein. It is used as a mild sedative, closely resembling potassium bromide in action.

Dose.—1 gramme (15 grains).

SODII CARBONAS MONOHYDRATUS—Monohydrated Sodium Carbonate

(Sod. Carb. Monohyd.)

It contains not less than 99.5 per cent. of $Na_2CO_3+H_2O$ (124.02). Preserve it in well-closed containers.

Summarized Description.

White crystalline powder; strongly alkaline; efflorescent in dry air or at 50°C.; soluble in about 3 parts of water and in 8 parts of glycerin; insoluble in alcohol. For details see U.S.P., p. 386.

For *tests for identity*, for *impurities* (heavy metals) and for *assay* see U.S.P., p. 387 and also Part V of this book.

Remarks.—Sodium carbonate, the next chemical demanding our attention, is, with the sole exception of sulphuric acid, the most widely used manufactured product in the chemical world. To mention all the many important industries in which sodium carbonate is a potent factor would occupy too much space, but chief among the branches of trade to which sodium carbonate is essential are soap-making and glass manufacture.

In early time the only source of sodium carbonate was by evaporation of water from certain soda lakes, such as *trona* from Egypt, or from the crude salt obtained by lixiviating the ashes of sea-weeds, rich in soda, such as *barilla* from Spain. The output from these sources was rather limited, and as the soap and glass industries became more important, the need for cheap sodium carbonate became more and more imperative, and, accordingly, a prize was offered by the Paris Academy, in 1782, for the best method of artificial production of this valuable alkali, and the prize was awarded to Nicholas Leblanc. In 1794 the French government took charge of his factory.

A most striking proof of the value of the process is shown by the fact that to this day a large amount of sodium carbonate is still manufactured by the Leblanc process.

In passing, it should be mentioned that Leblanc's process, like most other great discoveries, did not originate solely with the man whose name it bears. Duhamel in 1736 converted sodium chloride successfully into sodium sulphate, sodium sulphide, sodium acetate, and lastly into sodium carbonate. Marggraf, 1759, shortened the transformation by converting sodium chloride into sodium sulphate, then into sodium nitrate, and this, by strong heat, into the oxide which, on standing, absorbed enough carbon dioxide from the air to change into carbonate.

It is even said that the last portion of the Leblanc process (use of coal and limestone) was suggested to him by De la Mitherie, but be this as it may, it was Leblanc who established the first factory for the manufacture of sodium carbonate, and to him the real credit is due.

Leblanc chose as the sodium compound on which to begin operations that which was most widely distributed; that body which was found both on land and in the sea—sodium chloride or common salt. This is the cheapest sodium compound, and the only reason it is not used as the "stock salt" in chemical manufacturing—in making other sodium salts —is because of the difficulty with which it decomposes, there being very few acids which can break it up. Among these is sulphuric acid, the reaction being $2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$. Note that hydrochloric acid, HCl, is a side product in the process. In England, when the manufacture was first begun, the acid was allowed to escape with the air through tall chimneys, with most terrible results—as the vapor mingled with the aqueous vapor and fell with the latter as rain, destroying vegetation and ruining health. So great was the damage that stringent laws were enacted prohibiting the discharge of the acid vapor. Thereupon the manufacturers took to condensing the vapors and disposing of the hydrochloric acid, and by curious change of times, at present, the keen competition has so lessened the price of sodium carbonate that the manufacturers gain much of their profit from the sale of the acid.

But to return to the process, which we have only followed to the formation of sodium sulphate, and which seems as far off as was the chloride, Leblanc's genius solved the problem of conversion. He realized that while the sulph*ate* was a very stable body, the sulph*ide* was quite weak—could be replaced even by the CO_3 group.

The changing of the sulphate, Na_2SO_4, to the sulphide, Na_2S, is very simple. It is merely a process of reduction, and is performed by the reducing agent we used in the manufacture of sulphurous acid—the element carbon, usually in the form of common coal. The reaction is as follows:

$$Na_2SO_4 + C_2 = 2CO_2 + Na_2S.$$

Having converted the strong sulphate into the easily dissociated sulphide, the next step is to bring about a double decomposition between this sulphide and some cheap carbonate. The carbonate best answering this requirement is the calcium salt, which is abundantly found as marble, limestone, chalk, and oyster shells. This salt is accordingly employed, and the reaction is:

$$Na_2S + CaCO_3 = Na_2CO_3 + CaS.$$

In practice, the sulphate is heated with coal and limestone at the same time, hence the two actions run simultaneously.

The next process we have to consider is that which leads to the sodium bicarbonate instead of to the carbonate. This is the *Solvay process*, and is one of the most clear-cut processes we meet in chemistry, as both reaction products are valuable, and there is little waste-product. It is also called the "ammonia soda process," after the constituents employed.

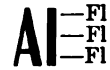
Like Leblanc's process, it starts off with that most abundant source of sodium, the chloride.

A solution of salt is placed in a tin-lined vat and is saturated with ammonia gas. This liquid, on cooling, is pumped into a second vat, where it absorbs carbon dioxide gas and forms sodium bicarbonate and ammonium chloride by the following reaction:

$$NaCl + NH_3 + H_2O + CO_2 = NaHCO_3 + NH_4Cl.$$

The process is comparatively modern, and is even now replacing the Leblanc process, as it is less wasteful and yields a finer and more attractive product.

The third method for obtaining the carbonic acid compounds of sodium is by the *cryolite process*, which is named from the Greenland mineral, which is the stock salt. Cryolite is a fluoride of aluminum and sodium, the formula of which is not so difficult if one only remembers that fluorine forms compounds entirely analogous to the chlorides, the bromides, and the iodides. Aluminum fluoride is $AlFl_3$, since aluminum is trivalent and the linkage is graphically as follows:



$$Al\begin{array}{l}-Fl\\-Fl\\-Fl\end{array}$$

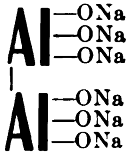
When written double, the formula is Al_2Fl_6. Sodium fluoride is NaFl—exactly analogous to NaCl. The proportions in which these two fluorides combine are six molecules of NaFl to one of Al_2Fl_6.

The method of manufacture of the sodium from cryolite has not the extended use that Leblanc's and Solvay's processes enjoy, it being practically a monopoly of one corporation.

Cryolite is first heated with limestone, and is thus converted into sodium aluminate and calcium fluoride, as shown in the following equation:

$$Al_2Fl_6 6NaFl + 6CaCO_3 = Al_2(ONa)_6 + 6CaFl_2 + 6CO_2.$$

The graphic formula of sodium aluminate is supposed to be as follows:



$$\begin{array}{l}Al\begin{array}{l}-ONa\\-ONa\\-ONa\end{array}\\ \mid\\ Al\begin{array}{l}-ONa\\-ONa\\-ONa\end{array}\end{array}$$

That is, aluminum hydroxide (p. 490) with its six atoms of hydrogen replaced by six atoms of sodium.

It is met with in analytic chemistry, one of the tests for aluminum being that any soluble salt of this metal, when treated with sodium hydroxide, yields a gelatinous precipitate, aluminum hydroxide, which is soluble in an excess of sodium hydroxide (p. 490).

Some investigators now claim that its formula is $Al(OH)_2ONa$, while others claim it is not a true salt but a colloidal condition.

In other words, when an excess of sodium hydroxide is added, the aluminum hydroxide combines with it to form a soluble aluminate of sodium, just described. This reaction is also employed in the separation of iron from aluminum in analytic work.

Returning to our cryolite process: the aluminate of sodium is converted into sodium carbonate by treatment with carbon dioxide gas by the following reaction:

$$Al_2(ONa)_6 + 3CO_2 = 3Na_2CO_3 + Al_2O_3.$$

The commercial value of this method of manufacturing sodium carbonate is due not only to the output of sodium carbonate, but also to the fact that the side-products—aluminum oxide and calcium fluoride—are worked up into the alums and the fluorine derivatives respectively.

Sodium carbonate is an antacid, but is not used much internally, the less irritating bicarbonate being preferred.

Dose.—250 milligrammes (4 grains).

Sodii Carbonas (U.S.P. 1890) was the crystalline dekahydrated form, that is, containing ten molecules of water of crystallization—$Na_2CO_3 10H_2O$. This is what is familiarly called *washing-soda*, and had the disadvantage of being very efflorescent; so much so that the writer has seen crystals of the salt lose water while still in the crystallizing vat. This made it a matter of difficulty to employ the salt in work involving molecular proportions; hence in the eighth revision the monohydrated salt was given official recognition. Because the monohydrated salt is both stable and concentrated, it replaced both the crystalline and the exsiccated carbonate of the old pharmacopœia.

Sodii Carbonas Exsiccatus (U.S.P. 1890).—This substance is made by taking dekahydrated sodium carbonate and exsiccating it at a temperature of about 45°C. (115°F.) until the product has lost half its weight. The object of using the heat of a water-bath is in order to avoid the possible loss of carbon dioxide. The dry carbonate is used for the same purpose as in the dekahydrated, but is about twice the strength, and is preferable for filling prescriptions of pills and powders.

SODII BICARBONAS—Sodium Bicarbonate

(Sod. Bicarb.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of $NaHCO_3$ (84.01). Preserve it in well-closed containers, in a cool place.

Summarized Description.

White, opaque powder; cooling, mildly alkaline taste; soluble in about 10 parts of water; insoluble in alcohol; aqueous solution loses carbon dioxide on boiling, being converted into the normal carbonate. For details see U.S.P., p. 383. For *tests for identity*, for *impurities* (ammonia, carbonate, heavy metals), and for *assay* see U.S.P., p. 383 and also Part V of this book.

Remarks.—While the commonly accepted formula for sodium bicarbonate is $NaHCO_3$, that is, H_2CO_3 with one atom of hydrogen replaced by one atom of sodium, Bicher claims for it the double formula $Na_2H_2(CO_3)_2$ and expresses this by means of an ingenious graphic formula.

The process for making this salt is the Solvay process just described. It can also be made by treating sodium carbonate with carbon dioxide, but such a process is no longer much employed.

Sodium bicarbonate usually occurs in the form of a white, opaque powder, which is soluble in 10 parts of water; therefore much less soluble than is the carbonate. Sodium bicarbonate is a popular antacid, being comparatively free from irritating action.

Dose.—1 gramme (15 grains).

Sodii chloras (U.S.P. VIII) $NaClO_3$ is made like potassium chlorate, by treating calcium chlorate with sodium chloride.

It can also be made by treating potassium chlorate with sodium bitartrate by the following equation:

$$KClO_3 \ + \ NaHC_4H_4O_6 \ = \ KHC_4H_4O_6 \ + \ NaClO_3.$$

The potassium bitartrate produced in the reaction precipitates from the solution as it does in the Fothergill process (p. 393).

Sodium chlorate so closely resembles potassium chlorate that extended comment is unnecessary. Like potassium chlorate, it must be handled carefully in reference to trituration with oxidizable bodies, in order to avoid an explosion.

Its only advantage over potassium chlorate is that it is more soluble in water, 1 part of the sodium salt dissolving in 1.1 parts of water, while 1 part of potassium chlorate requires 16.5 parts of water to make a solution. Its uses are about the same as those of potassium chlorate.

Dose.—250 milligrammes (4 grains).

SODII CHLORIDUM—Sodium Chloride

(Sod. Chlorid.)

It contains, when dried to constant weight at 110°C., not less than 99 per cent. of NaCl (58.46). Preserve it in well-closed containers.

Summarized Description.

Colorless cubical crystals or white, crystalline powder; purely saline taste; slightly hygroscopic; soluble in 2.8 parts of water; slightly soluble in alcohol; on heating, it decrepitates, then fuses and finally volatilizes. For details see U.S.P., p. 387. For *tests for identity*, for *impurities* (heavy metals, calcium, magnesium, bromide, iodide), and for *assay* see U.S.P., p. 387 and also Part V of this book.

Sodium chloride, or *common salt*, is one of the most valuable and ancient of the chemicals. It is essential to animal economy, hence it has been used from the earliest days. As mentioned above, it is the chief source of metallic sodium and of the sodium compounds, and is found in the native state widely distributed.

Its presence in sea-water, salt-wells, and salt mines has been mentioned, so here it is only necessary to state that, among the chief deposits of salt, are the mines near Cracow, in eastern Poland; near Salzburg, in Tyrol; and the Petit Anse mines of southwest Louisiana. In many parts of the world are found deposits of salt of not sufficient area to justify mining. In these cases shafts are sunk until the deposit is reached, water poured in, and when saturated with the salt, is pumped out and the solution evaporated. Such process is now carried on in Cleveland, O. Another source of salt is the natural salt springs found in certain sections of the world. There are many of these in Germany of insufficient concentration to justify the use of heat for complete evaporation, and in such cases the major portion of the water is removed by the application of spontaneous evaporation, explained on p. 89.

Normal saline solution, which is in some demand, is a $\frac{9}{10}$ of 1 per cent. solution of sodium chloride. It is presumably of the same saline strength as blood-serum, and is used for transfusion operations. This preparation is now official under the name of *physiological salt solution.* (See p. 188.)

Dose.—As emetic, 15 grammes (4 drachms).

SODII CITRAS—Sodium Citrate

(Sod. Cit.)

It contains not less than 98 per cent. of $Na_3C_6H_5O_7 + 2H_2O$ (294.07). **Preserve** it in well-closed containers.

Summarized Description.

White, granular powder; cooling saline taste; soluble in 1.3 parts of water; insoluble in alcohol; carbonizes at red heat, leaving a residue of carbonate. For details see U.S.P., p. 388.

For *tests for identity*, for *impurities* (arsenic, heavy metals) and for *assay* see U.S.P., p. 388 and also Part V of this book.

Remarks.—This official is made by treating sodium carbonate with citric acid. It, like the other alkaline citrates, has the property of holding in solution such insoluble bodies as ferric phosphate and magnesium carbonate. It is used as a refrigerant.

Dose.—1 gramme (15 grains).

Liquor Sodii Citrotartratis Effervescens (N.F.) is made by dissolving sodium bicarbonate in a solution of tartaric and citric acids, the product being flavored with syrup of citric acid. (See p. 192.) The recipe calls for 350 mils, which is to be dispensed in effervescent condition in a stout bottle. It is used as a purgative, like solution of magnesium citrate.

SODII CYANIDUM—Sodium Cyanide

(Sod. Cyanid.)

It contains not less than 95 per cent. of $NaCN$ (49.01). **Preserve** it in well-closed containers, protected from light.

NOTE.—Sodium Cyanide replaces Potassium Cyanide of the U.S.P. VIII.

Summarized Description.

White, opaque, amorphous pieces or white, granular powder, deliquescent in moist air, giving odor of hydrocyanic acid; freely soluble in water; extremely poisonous; handle with great caution. For details see U.S.P., p. 388.

For *tests for identity*, for *impurities* (ferrocyanide, sulphocyanate) and for *assay* see U.S.P., p. 388 and also Part V of this book.

Remarks.—This chemical replaces in the pharmacopœia, the long official potassium cyanide (see p. 419) and has been introduced to partly lessen the stringency due to shortage of potassium salts in this country. Its manufacture and uses resemble the potassium compound.

SODII GLYCEROPHOSPHAS—Sodium Glycerophosphate

(Sod. Glycerophos.—Sodium Glycerinophosphate)

Hydrated Sodium Glycerophosphate containing not less than 68 per cent. of the anhydrous salt [$Na_2C_3H_7PO_6$ or $C_3H_5(OH)_2PO_4Na_2 = 216.10$].

Summarized Description.

White, monoclinic plates or scales or white powder; saline taste; very soluble in water; almost insoluble in alcohol; carbonizes on heat, leaving residue of sodium pyrophosphate. For details see U.S.P., p. 389.

For *tests for identity*, for *impurities* (free alkali, alcohol-soluble matter, heavy metals, phosphates) and for *assay* see U.S.P., p. 389 and also Part V of this book.

Remarks.—This new official substance is the sodium salt of glycerophosphoric acid (see p. 612) and is now quite popular as a tonic. It is a constituent of solution of glycerophosphates N. F. (see next page).

Dose.—250 milligrammes (4 grains).

LIQUOR SODII GLYCEROPHOSPHATIS—Solution of Sodium Glycerophosphate

(Liq. Sod. Glycerophos.)

An aqueous solution of sodium glycerophosphate corresponding to not less than 50 per cent. of the anhydrous salt ($Na_2C_2H_7PO_6$ or $Na_2C_3H_5(OH)_2PO_4$ = 216.10).
Tests for Identity.—See sodium glycerophosphate.

Assay.—See Part V.

Remarks.—This new official solution is a commercial product intended to be used in place of the more costly crystalline sodium glycerophosphate. It is so employed in making the *compound elixir of glycerophosphates* N.F. (p. 209).

Dose.—0.35 mil (6 minims).

SODII HYPOPHOSPHIS—Sodium Hypophosphite

(Sod. Hypophos.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 98 per cent. of $NaPH_2O_2 + H_2O$ (106.07). Preserve it in well-closed containers. Caution should be observed in dispensing Sodium Hypophosphite, as an explosion is liable to occur when it is triturated or heated with nitrates, chlorates or other oxidizing agents.

Summarized Description.

Small, colorless, rectangular plates or white, granular powder; saline taste; somewhat deliquescent; soluble in about 1 part of water; and in alcohol; decomposes on heating, into phosphine. For details see U.S.P., p. 391.

For *tests for identity*, for *impurities* (alkali, phosphate, heavy metals, arsenic) and for *assay* see U.S.P., p. 391 and also Part V of this book.

Remarks.—This hypophosphite is prepared in a manner similar to that for making potassium hypophosphite—by treatment of calcium hypophosphite with sodium carbonate.

Sodium hypophosphite occurs in the form of small transparent plates, or chiefly in white, granular powder. It is soluble in 1 part of water and 30 parts of alcohol. Like all hypophosphites, the sodium hypophosphite must be heated with great care, as otherwise the following chemical reaction will occur:

$$5NaPH_2O_2 + \text{heat} = Na_4P_2O_7 + NaPO_3 + 2PH_3 + 2H_2,$$

the resulting phosphine (PH_3) being spontaneously combustible and producing an explosion.

Sodium hypophosphite is a constituent of the official *syrup of hypophosphites.* It may be here stated that hypophosphorous acid and hypophosphites act as reducing agents on silver and mercury compounds, hence the salts of these metals should not be prescribed with syrup of hypophosphites. Like all hypophosphites, the salt of sodium is used as a tonic and nutrient in wasting diseases.

Dose.—1 gramme (15 grains).

SODII IODIDUM—Sodium Iodide

(Sod. Iod.)

It contains, when dried to constant weight at 100°C., not less than 99 per cent. of NaI (149.92). It contains not more than 7 per cent. of moisture. Preserve it in well-closed containers.

Summarized Description.

Colorless, cubical crystals or white, crystalline powder; saline taste; deliquescent in moist air, turning brown; soluble in about 0.5 part of water, in about 1.6 parts of alcohol and in 1.25 parts of glycerin. For details see U.S.P., p. 392.

For *tests of identity*, for *impurities* (alkali, potassium, heavy metal, free iodine, iodate, barium, cyanide, nitrates, nitrites, thiosulphate, sulphate), and for *assay* see U.S.P., p. 392 and also Part V of this book.

Remarks.—This salt so closely resembles potassium iodide that little additional statement is needed here. It is made by the same processes used in the manufacture of potassium iodide and the bromides of potassium and sodium. Hence here it is only necessary to mention that treating sodium hydroxide with iodine, and subsequent heating of the evaporated mass with charcoal, will yield the iodide.

It occurs in anhydrous cubes or rhombic prisms, somewhat deliquescent, turning reddish brown on exposure to air, the latter change being due to liberation of iodine. It is used medicinally exactly as is potassium iodide.

Dose.—300 milligrammes (5 grains).

Sodii Nitras (U.S.P. VIII) $NaNO_3$ is a purified form of the native *Chile saltpeter.* Large deposits of this mineral are found in Peru, and is called Chile saltpeter because it is shipped through the Chilean ports. The native ore is a combination of sodium nitrate with sodium iodate, and the latter chemical, as mentioned on p. 378, yields practically all the iodine in use in the world. The iodate is removed from the nitrate by crystallization in the district where mined, and is there worked into iodine (p. 378), while the nitrate is shipped into commerce practically free from iodide.

Sodium nitrate has become of tremendous general importance, since Chile saltpeter has been the chief fertilizer of the world. The possibility of exhaustion of Chilean field caused scientists to sound a note of warning and attempts to make nitric acid and sodium nitrate synthetically were started. The feat was accomplished by Eydt, who makes nitric oxide by passing air through cylinders through which pass high tension electricity. The process is now being operated in Norway with great commercial success.

Sodium nitrate is the source of the commercial nitrates. It is rarely used in medicine, the potassium nitrate being preferred. When used, it is as a diuretic, as is potassium nitrate.

Dose.—1 gramme (15 grains).

SODII NITRIS—Sodium Nitrite

(Sod. Nitris)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 95 per cent. of $NaNO_2$ (69.01). Preserve it in well-closed containers.

Summarized Description.

White, opaque, fused masses or sticks, colorless hexagonal crystals or granular powder; mild saline taste; deliquescent on exposure to air and oxidizes to nitrate; soluble in 1.5 parts of water; slightly soluble in alcohol; on heating dissociates into oxygen, nitrogen, nitrogen dioxide and sodium oxide. For details see U.S.P., p. 393.

For *tests for identity*, for *impurities* (heavy metals) and for *assay* see U.S.P., p. 393 and also Part V of this book.

Remarks.—This salt is made by reduction of sodium nitrate by fusing with sheet lead. The fused mass is poured into water, the diluted solution treated with nitric acid until just neutral (thus precipitating the lead). The filtrate is then concentrated, when the sodium nitrite crystallizes out.

This salt occurs in the form of deliquescent granules, or usually in the form of fused pencils. It was introduced in the pharmacopœia in 1890, because used in the manufacture of spirit of nitrous ether, and has been retained in the present pharmacopœia for the same reason. It is now being used extensively in medicine since it has marked hypotensive action, making it as useful as nitroglycerin.

Dose.—60 milligrammes (1 grain).

SODII PHENOLSULPHONAS—Sodium Phenolsulphonate

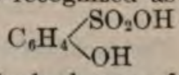
(Sod. Phenolsulph.—Sodium Sulphocarbolate)

It contains not less than 83.64 per cent. nor more than 87.82 per cent. of anhydrous sodium phenolsulphonate (sodium paraphenolsulphonate), corresponding to not less than 99 per cent. of the crystallized salt [$C_6H_5O{\cdot}SO_3Na + 2H_2O = 232.14$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, rhombic prisms or crystalline granules; cooling saline bitter taste; somewhat efflorescent; soluble in about 4.2 parts of water, in about 113 parts of alcohol and in 6 25 parts of glycerin; on heating it chars and incinerates to sodium sulphate. For details see U.S.P., p. 395.

For *tests for identity*, for *impurities* (heavy metals, phenol) and for *assay* see U.S.P., p. 395 and also Part V of this book.

Remarks.—This body, formerly called *sodium sulphocarbolate*, has a complex formula, $NaSO_3C_6H_4OH$. This is the sodium salt of sulphocarbolic acid, which is made by treating phenol (or carbolic acid) with sulphuric acid, whereby one hydrogen of C_6H_5OH (see graphic formula on p. 690) is replaced by the group SO_2OH, which will be recognized as sulphuric acid, less one hydroxyl. This union gives us  $C_6H_4\begin{cases} SO_2OH \\ OH \end{cases}$ sulphocarbolic acid, and the sodium in the salt replaces the hydrogen of the hydroxyl attached to the SO_2OH group.

Sodium sulphocarbolate is made by treating phenol with sulphuric acid, and letting stand for twenty-four hours, when sulphocarbolic acid is formed:

$$C_6H_5OH + H_2SO_4 = C_6H_4(SO_2OH)OH + H_2O.$$

To the acid mixture barium carbonate is added, thus forming barium sulphocarbolate, which is soluble, while the excess of sulphuric acid separates out as barium sulphate. To the filtered solution of barium sulphocarbolate, sodium carbonate is added, producing the following reaction:

$$Ba(SO_3C_6H_4OH)_2 + Na_2CO_3 = 2NaSO_3C_6H_4OH + BaCO_3.$$

The barium carbonate thus formed precipitates out and is separated by filtration from the solution of sodium sulphocarbolate, which is then concentrated by evaporation to a point where crystallization takes place.

Sodium sulphocarbolate occurs as transparent, colorless prisms, somewhat efflorescent, possessing a delicate pink tint. This coloration, however, is due to the same cause as is the pink color of phenol, and hence may possibly be considered as an impurity.

Sodium sulphocarbolate is used as an antiferment.

Dose.—250 milligrammes (4 grains).

SODII PHOSPHAS—Sodium Phosphate

(Sod. Phos.)

It contains not less than 39.25 per cent. nor more than 44.00 per cent. of anhydrous sodium phosphate (di-sodium-ortho-phosphate), corresponding to not less than 99 per cent. of the crystallized salt [$Na_2HPO_4 + 12H_2O = 358.24$]. **Preserve it in well-closed containers, in a cool place.**

Summarized Description.

Colorless, monoclinic prisms or granular salt; cooling saline taste; efflorescent; soluble in about 2.7 parts of water; insoluble in alcohol; on heating, is converted into sodium pyrophosphate. For details see U.S.P., p. 396.

For *tests for identity*, and for *impurities* (calcium, aluminum, heavy metals, carbonate, chloride, arsenic) see U.S.P., p. 396 and also Part V of this book.

Remarks.—The formula of sodium phosphate is worthy of special notice. On p. 358 will be found the graphic formula of phosphoric acid, H_3PO_4. If two of the three hydrogen atoms of phosphoric acid are replaced by sodium atoms (each atom of sodium of valence I replacing one atom of hydrogen), we get Na_2HPO_4, the formula of the official sodium phosphate.

All these hydrogen atoms found in phosphoric acid are replaceable under proper conditions, as illustrated in the formula of official calcium phosphate $Ca_3(PO_4)_2$ (p. 360), and a sodium phosphate having the formula Na_3PO_4 can be made. But the stable form of sodium phosphate is the one in which one atom of the hydrogen in the acid remains (Na_2HPO_4), and this is recognized by the pharmacopœia.

This important salt is prepared by treating bone-ash with sulphuric acid, when acid calcium phosphate is produced, as shown in the following equation:

$$Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4.$$

The solution of acid calcium phosphate, freed from the insoluble calcium sulphate by forcible straining, treated with sodium carbonate, yields sodium phosphate, as shown in the following equation:

$$CaH_4(PO_4)_2 + Na_2CO_3 = Na_2HPO_4 + CaHPO_4 + CO_2 + H_2O.$$

Other authorities say the reaction runs:

$$3CaH_4(PO_4)_2 + 4Na_2CO_3 = 4Na_2HPO_4 + Ca_3(PO_4)_2 + 4H_2O + 4CO_2.$$

Sodium phosphate occurs in the form of large, colorless, efflorescent crystals, although now usually dispensed in the form of granules. It is important for the pharmacist to remember that the granules are efflorescent, that they part comparatively easily with a portion of their water of crystallization, and thus lose a considerable amount of their weight. In fact, in the writer's experience, he has known of cases where a pound of sodium phosphate decreased to 12 ounces by weight by simple efflorescence. In selling the salt this should be kept in mind, otherwise a depreciation in the profit will result.

Recent literature has shown that a large amount of sodium phosphate on the market is contaminated with arsenic, and therefore the pharmacist should examine his phosphate in order to prevent dispensing a dangerous chemical. An interesting preparation of the salt is a combination of it with sodium nitrate and citric acid. When these three chemicals are triturated together in a warm mortar, they liquefy, forming a solution containing over 100 per cent. by volume of sodium phosphate. A similar preparation is *compound solution of sodium phosphate* N.F.

Medical Properties.—A valuable saline purgative.

Dose.—4 grammes (1 drachm).

SODII PHOSPHAS EFFERVESCENS—Effervescent Sodium Phosphate

For details of manufacture see Part VII.

Remarks.—This is a granular effervescent salt containing 20 per cent. exsiccated sodium phosphate. Note that the pharmacopœia directs that the mass be softened for granulation by warming and not by moistening with alcohol. It is a useful and agreeable purgative.

Dose.—10 grammes (2½ drachms).

SODII PHOSPHAS EXSICCATUS—Exsiccated Sodium Phosphate

(Sod. Phos. Exsic.)

It contains, when dried to constant weight at 110°C., not less than 98 per cent. of Na_2HPO_4 (142.05). Preserve it in well-closed containers.

Condensed Recipe.

Allow crystals of sodium phosphate to effloresce at 25° to 30°C. for several days, then heat in an oven to 100°C. until the salt ceases to lose weight. Then powder and sift. For details see U.S.P.

Summarized Description.

White powder; soluble in about 8 parts of water; insoluble in alcohol. For details see U.S.P., p. 397.

For *tests for identity* and for *impurities* see sodium phosphate. For *assay* see U.S.P., p. 397 and also Part V of this book.

Remarks.—This is used for the manufacture of the granular effervescent salt just described. Note that its dose is just half of that of the crystalline salt.

Dose.—2 grammes (30 grains).

Sodii Pyrophosphas (U.S.P. VIII) or *sodium pyrophosphate*, $Na_4P_2O_7$, introduces us to an acid of phosphorus not yet considered—pyrophosphoric. On a preceding page (p. 429), under Borax, mention was made of the fact that the prefix "pyro-" indicates application of strong heat; this applies to pyrophosphoric acid.

On p. 359 the difference between true orthophosphoric acid, H_5PO_5, the so-called orthophosphoric acid, H_3PO_4, and metaphosphoric acid, HPO_3, is graphically demonstrated, and mention is there made that all phosphoric acids are derived from phosphoric oxide, P_2O_5, a body in which phosphoric acid acts with valence v.

If to P_2O_5 we add one molecule of water, we get metaphosphoric acid, viz.,

$$P_2O_5 + H_2O = H_2P_2O_6 \text{ or } 2HPO_3;$$

and if we add three molecules of water to one molecule of phosphoric oxide, we get the official phosphoric acid, viz.,

$$P_2O_5 + 3H_2O = H_6P_2O_8 \text{ or } 2H_3PO_4.$$

Likewise, if we subtract one molecule of water from official phosphoric acid, we get metaphosphoric acid, viz.,

$$H_3PO_4 - H_2O = HPO_3.$$

If, on the other hand, we subtract one molecule of water from two molecules of official phosphoric acid, we get pyrophosphoric acid, as shown below:

$$\begin{array}{lcl} & 2H_3PO_4 = & H_6P_2O_8 \\ \text{Less one molecule of water or} & & \underline{H_2\ \ O} \\ \text{Give pyrophosphoric acid} & & H_4P_2O_7. \end{array}$$

The pyrophosphate is obtained by heating sodium phosphate until its solution no longer gives a yellow precipitate with silver nitrate.

Sodium pyrophosphate occurs in the form of a crystalline powder or in monoclinic prisms, and is soluble in 12 parts of water. It is rarely employed in medicine.

Dose.—2 grammes (30 grains).

SODII SALICYLAS—Sodium Salicylate

(Sod. Salicyl.)

It contains, when dried to constant weight at 100°C., not less than 99.5 per cent. of $NaC_7H_5O_3$ (160.04). Preserve it in well-closed containers, protected from heat and light.

Summarized Description.

White, micro-crystalline powder; scales or amorphous powder; colorless to faint pink; sweet saline taste; soluble in about 0.9 part of water and in about 7.5 parts of alcohol; on heating, it chars leaving residue of sodium carbonate. For details see U.S.P., p. 398.

For *tests for identity*, for *impurities* (sulphites, thiosulphates, heavy metals) and for *assay* see U.S.P., p. 398 and also Part V of this book.

Remarks.—This salt is prepared by treating salicylic acid with sodium carbonate, and evaporating the resulting solution of sodium salicylate to dryness in the water-bath. Many modern therapeutists claim that the salicylic acid employed should be that from oil of wintergreen. Calls for "Sodium salicylate (natural)" can be easily filled by the retail pharmacist by treating oil of wintergreen with the molecular quantity of sodium hydroxide, evaporating the mass to dryness, redissolving in water, making the solution acid by the addition of more salicylic acid, and granulating the resulting filtered liquid. The addition of extra acid is essential, for the alkaline sodium salicylate is invariably of grayish color. In preparing the sodium salicylate great care must be taken to avoid contact with iron, as that element will color the salicylate a blood red. (See p. 709.)

Sodium salicylate is a valuable remedy for rheumatism.

Dose.—1 gramme (15 grains).

Sodium silicate, Na_2SiO_3, was recognized in the pharmacopœia of 1890 as a nearly saturated solution (*liquor sodii silicatis* or *liquid glass*). It is made by fusing together common sand and sodium carbonate in the presence of a small quantity of charcoal. The fused mass is poured into water in order to obtain the product in small porous masses, which are more readily soluble.

Sand is silicic oxide, SiO_2, an exact analogue to carbonic oxide, CO_2. Silicic oxide plus sodium carbonate gives us sodium silicate and gaseous carbonic oxide:

$$SiO_2 + Na_2CO_3 = Na_2SiO_3 + CO_2.$$

Solution of sodium silicate is a more or less transparent, but faintly yellowish, viscid liquid, the keeping of which is a source of considerable annoyance to the retail pharmacist. If kept in glass-stoppered bottles it will cause the stopper to stick to the neck. It usually is somewhat alkaline, and therefore attacks cork, and if not tightly corked, it will comparatively easily evaporate to a glassy mass, which is quite difficult to redissolve. This body is called *liquid glass* or *water glass*, because of its resemblance to ordinary glass, which is a combination of sodium silicate with the silicates of lead and calcium.

Liquid glass forms, on drying, a vitreous coating which is hard and inflexible. Accordingly, it is used in mending fractured limbs, as is also plaster of Paris, the broken member being swathed with bandages which are fixed firmly in their place by applications of the liquid glass. After standing, the solution solidifies to a hard, rigid mass, which securely and firmly encases the limb.

It is superior to plaster of Paris in the greater ease with which the glass dressing can be removed after the limb is set.

The plaster has to be chipped off—a very tiresome operation; the glass, on the other hand, can be dissolved off with hot water.

It is found, however, that liquid glass sets too slowly for the average operation, and plaster-of-Paris settings are, therefore, usually preferred.

SODII SULPHAS—Sodium Sulphate

(**Sod. Sulph.**—Glauber's Salt)

It contains not less than 43.64 per cent. nor more than 48 per cent. of anhydrous sodium sulphate, corresponding to not less than 99 per cent. of the crystallized salt $[Na_2SO_4 + 10H_2O = 322.23]$. Preserve it in well-closed containers, in a cool place.
Summarized Description.

Large, colorless, efflorescent, monoclinic prisms or granular crystals; bitter saline taste; soluble in about 1 part of water at 25°C. (see below); insoluble in alcohol; fuses in its water of crystallization at 33°C. For details see U.S.P., p. 398.

For *tests for identity*, for *impurities* (heavy metals, arsenic) and for *assay* see U.S.P., p. 399 and also Part V of this book.

Sodium sulphate is known by the synonym of *Glauber's salt*, so named after John Rudolph Glauber, who published the process of manufacture in his work, "De Natura Salium," 1658. It is made by treating sodium chloride with sulphuric acid, and is, therefore, an intermediate product in the Leblanc process (p. 432).

Native sodium sulphate had been used many years before this.

Sodium sulphate occurs in efflorescent, monoclinic prisms or granular crystals, possessing a bitter, saline taste. Its solubility in water is noteworthy, the following table showing its variations from 0 to 100°C.:

At	0°C.	1	part	crystalline	sodium	sulphate	dissolves	in	8	parts	of	water.
At	15°C.	1	"	"	"	"	"	"	2.8	"	"	"
At	25°C.	1	"	"	"	"	"	"	1	part	"	"
At	30°C.	1	"	"	"	"	"	"	0.5	"	"	"
At	34°C.	1	"	"	"	"	"	"	0.25	"	"	"
At	50°C.	1	"	"	"	"	"	"	0.37	"	"	"
At	100°C.	1	"	"	"	"	"	"	0.40	"	"	"

the temperature being, of course, that of the water.

By this table it will be noted that the maximum solubility is reached at 34°C., when one part of the salt (crystals) will dissolve in one-quarter its weight of water. At 35°C. the solubility is 1 part in 0.3 part water, and from that to 100° the solubility slowly decreases. This phenomenon has been explained by claiming that up to 34°C. we deal with solution of the salt containing ten molecules of water of crystallization. At 34° it is supposed that the salt loses nine molecules of water, and from that time on we deal with a chemical possessing only one molecule of water of crystallization. The solution of sodium sulphate at 34° is a striking illustration of a supersaturated solution. Such a solution will remain intact if kept in a quiet place, even though the temperature of the solution be reduced below 33°. If the flask is shaken, or even if the cork is removed, there will be a sudden formation of crystals, with the evolution of considerable heat, corresponding to the phenomenon of *retarded crystallization*. (See p. 123.) The crystallization due to agitation is easy to understand. One explanation of why the crystallization takes place by merely removing the cork is that the air contains minute crystals of sodium sulphate, which, when the cork is removed, fall into the solution and act as nuclei

Sodium sulphate is a useful purgative.

Dose.—15 grammes (240 grains).

Sal Carolinum factitium (N.F.), or *artificial Carlsbad salt*, is mentioned here since sodium sulphate is its chief constituent, the other ingredients being sodium chloride and bicarbonate and potassium sulphate. The Formulary gives two recipes, one for an amorphous, the other for a crystalline form.

Sal Carolinum factitium effervescens (N.F.) is an effervescent variety of the foregoing containing 26.6 per cent. of the amorphous salt made into effervescent granules with sodium bicarbonate and tartaric and citric acids.

SODII SULPHIS EXSICCATUS—Exsiccated Sodium Sulphite

(Sod. Sulphis Exsic.)

It contains not less than 90 per cent. of Na_2SO_3 (126.07). Preserve it in well-closed containers, in a cool place.

Summarized Description.

White powder; cooling saline, sulphurous taste; in air oxidizes to the sulphate; soluble in about 3.2 parts of water; somewhat soluble in alcohol; dissociates on heating to the sulphide and the sulphate. For details see U.S.P., p. 399.

For *tests for identity*, for *impurities* (thiosulphate, heavy metals) and for *assay* see U.S.P., p. 399 and also Part V of this book.

Remarks.—This chemical is made by passing sulphur dioxide gas, produced in the way as explained under sulphurous acid (p. 402), into a solution of sodium carbonate, and then carbonating the solution. It is used as an antiferment.

Dose.—1 gramme (15 grains).

SODII THIOSULPHAS—Sodium Thiosulphate

(Sod. Thiosulph.—Sodium Hyposulphite)

It contains not less than 63.07 per cent. nor more than 67.48 per cent. of anhydrous sodium thiosulphate, corresponding to not less than 99 per cent. of the crystallized salt [$Na_2S_2O_3 + 5H_2O = 248.22$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, monoclinic prisms; cooling, then bitter taste; efflorescent above 33°C.; soluble in about 0.5 part of water; insoluble in alcohol; dissociated on high heat to sulphur, sulphide and sulphate. For details see U.S.P., p. 400.

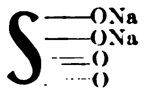
For *tests for identity*, for *impurities* (sulphites, bisulphites, arsenic, heavy metals, calcium) and for *assay* see U.S.P., p. 400 and also Part V of this book.

Remarks.—This salt has been incorrectly called sodium hyposulphite. In the table of valences on p. 352 it will be found that the valence of sulphur is II, IV, and VI.

As already learned, when an element has three valences and three oxides, the oxide showing the highest valence is given the termination "ic," while the oxide showing the lowest valence has "hypo" prefixed to the name of the positive element, whose termination becomes "ous." Under this rule, that oxide in which sulphur acts with the valence II should be termed hyposulphurous oxide, and the formula of this body is SO.

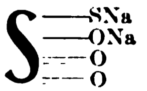
If hyposulphurous oxide be SO, then hyposulphurous acid will be $SO + H_2O$ or H_2SO_2, and sodium hyposulphite will be Na_2SO_2, which is quite different from the formula given above; the so-called sodium hyposulphite, $Na_2S_2O_3$, being really sodium thiosulphate. "*Thios*" is Greek for sulphur, hence the literal translation of thiosulphate is "sulphosulphate," a most appropriate title for the body $Na_2S_2O_3$, as is shown by the following comparison of the graphic formula of it with that of normal sodium sulphate:

SODIUM SULPHATE



$$S\begin{cases} -ONa \\ -ONa \\ =O \\ =O \end{cases}$$

SODIUM THIOSULPHATE



$$S\begin{cases} -SNa \\ -ONa \\ =O \\ =O \end{cases}$$

Sodium thiosulphate, $Na_2S_2O_3$, can be resolved into Na_2SO_3 (sodium sulphite) and sulphur, and inversely the thiosulphate can be made by boiling the sulphite with sulphur.

The commercial method of manufacture is by treating calcium thiosulphate with sodium sulphate, as shown in the following equation:

$$CaS_2O_3 + Na_2SO_4 = CaSO_4 + Na_2S_2O_3.$$

The calcium thiosulphate used in the above reaction is obtained from the calcium sulphide residue of the Leblanc process (p. 432). On exposure to air the calcium sulphide found therein is oxidized to calcium thiosulphate, which is lixiviated from the insoluble matter of the residue. Sodium thiosulphate is also made by cooking sulphur with sodium sulphite.

Sodium thiosulphate occurs in colorless, transparent crystals, soluble in less than one part of water. It is used largely in commerce, being a valuable antichlor in paper manufacture. It is the "hypo" of photographers, being used by them as a developer (see p. 561), it having the power of dissolving the chloride and bromide of silver. When brought in contact with an iodine solution, it immediately discharges the color of same, as explained on p. 378. The decolorizing influence of sodium thiosulphate on iodine is applied in the estimation of the iodine strength of various pharmaceuticals, the same being titrated with decinormal solution of sodium thiosulphate. Sodium thiosulphate has been recommended as exhibiting all the therapeutic value of sulphur in a soluble form, it being stated, when a solution enters the stomach, the acids thereof throw out a sufficient amount of sulphur to become active. In the same way the ointment of sodium hyposulphite has been recommended in place of sulphur ointment.

Dose.—1 gramme (15 grains).

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CHAPTER XXVII

LITHIUM AND AMMONIUM

LITHIUM

Symbol, Li. Atomic weight, approximately 7.

THE word lithium is derived from the Greek "*lithios*," meaning "stone," being so named by Berzelius because found in minerals. The presence of the new element was first detected by Arfvedson in 1817, but its isolation in more than traces was not accomplished until 1855, when Bunsen and Mattiessen obtained it by electrolysis of fused lithium chloride.

The chief ores of lithium are *lepidolite*, a combination of the silicates of lithium, sodium, and aluminum, and *triphylite*, which is a mixture of the phosphates of lithium, sodium, iron, manganese, and calcium.

It was first discovered in mineral water by Berzelius (1822), who noted its presence in Carlsbad water.

It is also found in tobacco and in the sugar-beet.

The metal cannot be isolated by chemical means, such as are used in obtaining sodium and potassium, by reason of the non-volatile character of the metal, but is prepared only by electrolysis of the chloride.

Lithium is the lightest of all metals, having the specific gravity 0.534, *i.e.*, it has less than six-tenths the weight of water, and is lighter than petroleum or ether, and hence floats on both of these liquids. It is a soft, silvery-white metal, possessing characteristics similar to that of the other members of the group, sodium and potassium, although being less chemically active. Thus, while it reacts in water with the formation of lithium hydroxide, it does not do so with explosive violence that characterizes the same reaction in the case of sodium and potassium.

The most characteristic test for lithium is the crimson color which it or its salts transmits to a colorless flame which is so sensitive that one-one-hundredth thousandth of a milligramme of lithium in 1 mil of water can be thus detected. If the solution of the chloride be treated with ammonium carbonate, the rather sparingly soluble carbonate is precipitated. This carbonate is somewhat soluble in water, however (1 part in 75 parts water), hence the statement already made (p. 407) that the carbonates of the alkalis dissolve in water still obtains.

The following salts of lithium are official:

Lithium bromide, 85 per cent. absolute LiBr.
Lithium carbonate, 98.5 per cent. absolute Li_2CO_3.
Lithium citrate, 98.5 per cent. absolute $Li_3C_6H_5O_7 + 4H_2O$.

LITHII BROMIDUM—Lithium Bromide

(Lith. Brom.)

It contains not less than 85 per cent. of LiBr (86.86). Preserve it in air-tight containers.

Summarized Description.

White, deliquescent, granular salt; sharp, slightly bitter taste; soluble in 0.6 part of water and also in alcohol; fused at red heat and then volatilizes. For details see U.S.P., p. 257.

For *tests for identity*, for *impurities* (other alkalies, iodide, bromate, chloride, sulphate, heavy metals) and for *assay* see U.S.P., p. 257 and also Part V of this book.

Remarks.—This salt is made by treating lithium carbonate with potassium bromide, as shown in the following equation:

$$Li_2CO_3 + 2KBr = K_2CO_3 + 2LiBr,$$

or by treating lithium sulphate with potassium bromide. In both cases the potassium salt—the carbonate or the sulphate—is precipitated from the lithium bromide solution by the addition of a small quantity of alcohol. Yvon's process of preparation is by treating lithium carbonate with bromine and then passing hydrogen sulphide through the mixture until the color of the bromine has disappeared. In this case the sulphide acts on the bromine to form hydrobromic acid and sulphur, the latter precipitating. The hydrobromic acid, in turn, acts on the lithium carbonate to form lithium bromide, and the result of the reaction is a solution of lithium bromide containing a precipitate of sulphur, which is removed by filtration. The filtered liquid is concentrated by evaporation and crystallized by desiccation, under the bell-glass, with sulphuric acid. A fourth process suggested is by treating ferrous bromide with lithium carbonate, and is, therefore, similar to the process for making potassium bromide. (See p. 414.)

Lithium bromide is used as a hypnotic.

Dose.—1 gramme (15 grains).

Lithii benzoas (U.S.P. VIII) or *lithium benzoate*, $LiC_7H_5O_2$ is made by treating lithium carbonate with benzoic acid, as shown in the following equation:

$$Li_2CO_3 + 2HC_7H_5O_2 = 2LiC_7H_5O_2 + H_2O + CO_2.$$

It occurs in a light white powder or small, shiny scales, and is used as a diuretic and as a remedy for gout.

Dose.—1 gramme (15 grains).

LITHII CARBONAS—Lithium Carbonate

(Lith. Carb.)

It contains, when dried to constant weight at 100°C., not less than 98.5 per cent. of Li_2CO_3 (73.88). Preserve it in well-closed containers.

Summarized Description.

Light, white powder; alkaline taste; soluble in about 78 parts of water; almost insoluble in alcohol; fuses at red heat losing carbon dioxide and leaving lithium oxide. For details see U.S.P., p. 258.

For *tests for identity*, for *impurities* (iron, aluminum, other alkalies, heavy metals) and for *assay* see U.S.P., p. 258 and also Part V of this book.

Remarks.—Lithium carbonate is prepared from lepidolite by making a paste of the finely powdered ore with concentrated sulphuric acid, calcining, and treating the residue with water. This throws out silicic acid, and converts the metals into sulphates, which go into solution. To the solution, potassium sulphate is added, when, on concentration, the aluminum crystallizes out as alum. To the remaining solution of the sulphates of sodium, potassium, and lithium, sodium carbonate is added, when crude lithium carbonate precipitates. This is purified by cooking with milk of lime or with aluminum hydroxide, when a solution of lithium hydroxide results, and from this the carbonate is produced by use of sodium carbonate. Lithium carbonate is also made by adding the chloride to warm 20 per cent. ammonium carbonate solution, or to solution of ammonium carbonate containing ammonia water.

Lithium carbonate is used in gout because it is supposed to exert a solvent action upon uric acid.

Dose.—500 milligrammes (8 grains).

LITHII CITRAS—Lithium Citrate

(Lith. Cit.)

It contains not less than 98.5 per cent. of $Li_3H_5C_6O_7 + 4H_2O$ (281.92). **Preserve** it in air-tight containers.

Summarized Description.

White powder or granules; cooling, faintly alkaline taste; deliquescent; soluble in about 1.4 parts of water; slightly soluble in alcohol; on heating it carbonizes, leaving lithium carbonate. For details see U.S.P., p. 258.

For *tests for identity*, for *impurities* (other alkalies, heavy metals) and for *assay* see U.S.P., p. 259 and also Part V of this book.

Remarks.—This salt is made by treating the lithium carbonate with citric acid, and crystallization of the citrate by evaporation of the solution. Its use is the same as that of the carbonate, but has the advantage of possessing a less disagreeable taste, and is more easily tolerated by the stomach.

Dose.—500 milligrammes (8 grains).

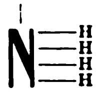
Sal lithii citras effervescens (N.F.), or *effervescent lithium citrate*, is a 5 per cent. mixture of lithium citrate with sodium bicarbonate, dried tartaric acid, and crystalline citric acid, granulated by softening the mass with heat and rubbing through a coarse sieve.

Lithii salicylas (U.S.P. VIII; N.F. IV), or *lithium salicylate*, $LiC_7H_5O_3$, is prepared by treating lithium carbonate with salicylic acid, heating until the effervescence ceases, and then granulating. The salt occurs in the form of a grayish-white, deliquescent powder, having a sweetish taste, very soluble in both alcohol and water. Lithium salicylate is a popular remedy for rheumatism and gout, since it possesses the antirheumatic properties of both salicylic acid and lithium.

Dose.—1 gramme (15 grains).

AMMONIUM

Ammonium is discussed as an element, although we know it is a compound and have no proof that it exists in a free state. By ammonium we mean the radicle NH_4. Graphically,

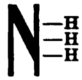


The discussion of radicles found on pp. 573, 574 will explain how NH_4, with one free bond, can act like a metal with one free bond.

The only inkling we have of the metallic character of ammonium and the possibility of its eventual isolation come from the fact that, by electrolysis of ammonium hydroxide in the presence of mercury, there is formed an amalgam of ammonium with mercury similar to that yielded by metallic sodium or potassium with the same liquid elements.

This amalgam, on being heated, splits into mercury, ammonia (NH_3), and hydrogen.

Do not confound *ammonium* with *ammonia*. Ammonia is a gas of sharp, penetrating odor, characteristic of spirit of hartshorn, having the formula NH_3, or, graphically,



$$N\begin{matrix}-H\\-H\\-H\end{matrix}$$

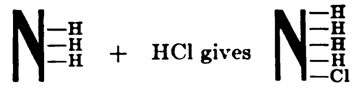
It is a definite chemical in which all three of the nitrogen bonds are satisfied by hydrogen. Ammonium is a radicle, showing nitrogen with five bonds and only four of these taken up by hydrogen, leaving one free bond ready for action. The formation of ammonium compounds from ammonia is different from metallic combinations. If we treat a metal—say, potassium—with hydrochloric acid, hydrogen is evolved and a chlorde is formed, thus—

$$K + HCl = KCl + H.$$

If, on the other hand, we treat ammonia with hydrochloric acid, ammonium chloride is formed without evolution of hydrogen, thus—

$$NH_3 + HCl = NH_4Cl,$$

or, graphically,



$$N\begin{matrix}-H\\-H\\-H\end{matrix} + \text{HCl gives } N\begin{matrix}-H\\-H\\-H\\-H\\-Cl\end{matrix}$$

Again, let it be reiterated that *sodium* (Na) is not *soda* (NaOH), *potassium* (K) is not *potash* (KOH), and *ammonium* (NH_4) is not *ammonia* (NH_3).

Ammonia, as just mentioned, is a gas having the formula of NH_3. This body is interesting as one of the few volatile alkalis (the others being organic chemicals), and its presence in compounds is generally detected by means of its volatility, the suspected substance being treated with soda or potassa and heated; if ammonium compounds are present, the ammonia gas is evolved, and is readily recognized by its characteristic odor. If only minute quantities of the gas are evolved, it can be detected by means of moistened red litmus-paper, which will turn blue upon being applied to the vapors of ammonia. When ammonia gas comes in contact with hydrochloric acid, white fumes of ammonium chloride are formed. In testing for minute quantities of ammonia, Nessler's reagent is employed. This consists of a solution of mercuric iodide in an excess of mercuric chloride, and when this colorless or faintly straw-colored liquid is added to the solution containing ammonia, the liquid is then changed to either an amber tint or a red-brown precipitate is produced, according to the amount of ammonia present. By this means small quantities of ammonia (even 1 part to 10,000,000) can be detected in a liquid.

The test is too sensitive for application in ordinary analytic processes, but is invaluable in detecting ammonia in drinking-water, as already explained on p. 369.

Ammonia gas was first prepared by Priestly, in 1774, by heating ammonium chloride with slaked lime, the reaction being:

$$2NH_4Cl + Ca(OH)_2 = CaCl_2 + 2NH_3 + 2H_2O.$$

The evolved gas he called "alkaline air," the word ammonia (of Ammoniack) being first applied to it by Bergman in 1782.

Commercial ammonia gas is made from the ammoniacal liquor or gas-works. In the manufacture of illuminating-gas from coal the gas, as it leaves the retort, is passed through diluted sulphuric acid to remove the ammonia produced from the coal. In this way the acid liquid eventually becomes a solution of ammonium sulphate, and the crude sulphate obtained by evaporation of the solution is sold to the chemical manufacturers. By treating this crude sulphate with slaked lime the ammonia gas is evolved, and on being passed into water, forms the commercial solution of ammonia.

AQUA AMMONIÆ—Ammonia Water

(Aq. Ammon.)

An aqueous solution of ammonia [NH_3 = 17.03] containing not less than 95. per cent. nor more than 10.5 per cent. by weight of NH_3. This solution deteriorates on keeping, and must be tested frequently. Preserve it in a cool place in glass-stoppered bottles made of hard glass free from lead.

Summarized Description.

Colorless liquid; pungent odor; caustic, alkaline taste; fumes, when brought near concentrated hydrochloric acid; sp. gr. 0.958. For details see U.S.P., p. 53.

For *tests for identity*, for *impurities* (readily oxidizable matter, heavy metals, non-volatile matter) and for *assay* see U.S.P., p. 53 and also Part V of this book.

Dose.—1 mil (15 minims).

AQUA AMMONIÆ FORTIOR—Stronger Ammonia Water

(Aq. Ammon. Fort.)

An aqueous solution of ammonia [NH_3 = 17.03] containing not less than 27 per cent. nor more than 29 per cent., by weight, of NH_3. This solution deteriorates on keeping, and must be tested frequently. Preserve it in a cool place in partially filled, strong, glass-stoppered bottles made of hard glass free from lead. *Great caution should be used in handling this liquid.*

Summarized Description.

Colorless liquid; very strong odor; very caustic; strongly alkaline; sp. gr. 0.897. For details see U.S.P., p. 54.

For *tests for identity* and for *impurities*, see ammonia water. For *assay* see U.S.P., p. 54 and also Part V of this book.

Remarks.—It will be seen that the pharmacopœia recognizes two strengths of ammonia water—the ordinary, containing about 10 per cent., by weight, of ammonia gas, and the stronger water, which contains about 28 per cent. of the same gas and represents a saturated solution. Unfortunately, as is usual with commercial chemicals, ammonia is not always sold by percentage of ammonia gas, but by the arbitrary marking of degrees.

The "degrees" mean the graduations of the Baumé scale of light liquids (see p. 50), and must not be confounded for the percentage.

Thus, 17° ammonia, largely sold by wholesalers, does not contain 17 per cent. ammonia gas, but represents the specific gravity 0.953, which means only 11½ per cent. ammonia gas.

To render the subject still more vague, some wholesalers substitute for degrees Baumé arbitrary markings. "F," "FF," "FFF," and even "FFFF." Presumably the first stands for "fortis" (strong), the second for "fortior" (stronger), and the third for "fortissimus" (strongest). In this case 4 F is outdoing the superlative.

When ammonia gas is run into water, ammonium hydroxide is produced by a reaction similar to that just cited as occurring between ammonia and hydrochloric acid. The reaction is:

$$NH_3 + HOH = NH_4OH,$$

the valence of nitrogen changing from III to V during the process.

This theory is disputed by Tommasi, who, from physical and thermic experiments, concluded that ammonia water is simply a solution of NH_3 gas in water.

Ammonia water (10 per cent.) is called *spirit of hartshorn* because originally made by the destructive distillation of the horn of the hart (*Cornu cervi*). Regarding the stronger ammonia water, containing 28 per cent. of ammonia gas, nothing need be added to what has already been said on p. 171.

Spiritus ammoniæ (U.S.P. VIII), or *spirits of ammonia*, is an alcoholic solution of ammonia containing 10 per cent. of the gas. The recipe of the former pharmacopœia directed that the gas driven off from stronger ammonia water by heat be passed into alcohol; a procedure that the writer found both cumbersome and useless; since it was almost impossible to so obtain a 10 per cent. product.

LINIMENTUM AMMONIÆ—Ammonia Liniment

This will be discussed among the soaps on p. 666.

Liquor ammoniæ anisatus is a preparation in considerable demand in German neighborhoods. A recipe for it is found in the National Formulary. (See p. 183.)

AMMONIUM SALTS

Ammonium salts all contain the radicle NH_4, which acts very much like the elements sodium and potassium. Thus, while the formula of sodium bromide is NaBr, so the formula of ammonium bromide is NH_4Br; as the formula of potassium sulphate is K_2SO_4, so that of ammonium sulphate is $(NH_4)_2SO_4$.

The following ammonium salts and their preparations are official:

Solution of ammonium acetate containing about 7 per cent.	$NH_4C_2H_3O_2$.
Ammonium benzoate 98 per cent. absolute	$NH_4C_7H_5O_2$.
Ammonium bromide 98.5 per cent. absolute	NH_4Br.
Ammonium carbonate varying proportions of	NH_4HCO_3 and $NH_4NH_2CO_2$.
Aromatic spirit of ammonia. A pharmaceutical.	
Ammonium chloride 99.5 per cent. absolute	NH_4Cl.
Troches of ammonium chloride. A pharmaceutical.	
Ammonium iodide 99 per cent. absolute	NH_4I.
Ammonium salicylate 98 per cent. absolute	$NH_4C_7H_5O_3$.
Ammonium valerate more or less definite	$NH_4C_5H_9O_2$.

LIQUOR AMMONII ACETATIS—Solution of Ammonium Acetate

(Liq. Ammon. Acet.—Spirit of Mindererus)

An aqueous solution containing not less than 7 per cent. of $NH_4C_2H_3O_2$ (77.07), with small amounts of acetic and carbonic acids.

Condensed Recipe.

Dissolve 5 Gm. ammonium carbonate, in hard translucent pieces in 100 mils of diluted acetic acid. For details see U.S.P.

Summarized Description.

Clear, colorless liquid, mildly saline, acidulous taste; acid reaction. For details see U.S.P., p. 237.

For *tests for identity*, for *impurities* (non-volatile matter) and for *assay* see U.S.P., p. 237 and also Part V of this book.

Remarks.—This solution, which contains about 7 per cent. of the salt, and which is known by the synonym of *spirit of mindererus*, is made by adding 5 grammes of ammonium carbonate to 100 mils of diluted acetic acid, and the pharmacopœia directs that it should be freshly prepared when desired. The object of directing its being fresh is in order that the product will reach the patient in a slightly effervescent form, although the pharmacist must be careful not to cork the bottle while there is sufficient effervescence to produce an explosion. The pharmacopœia of 1880 directed a more convenient process of manufacture by ordering the ammonium carbonate to be dissolved in water and acetic acid be diluted with sufficient water, so that by mixing equal quantities of the two solutions a 7 per cent. solution of ammonium acetate will be produced. It seems unfortunate that this very convenient and simple process was dropped.

Solution of ammonium acetate is a refreshing refrigerant.

Dose.—15 mils (4 fluidrachms).

AMMONII BENZOAS—Ammonium Benzoate

(Ammon. Benz.)

It contains, when dried for twenty-four hours in a desiccator over sulphuric acid, not less than 98 per cent. of $NH_4C_7H_5O_2$ or $C_6H_5 \cdot COONH_4$ (139.08). Preserve it in well-closed containers in a cool place.

Summarized Description.

Thin, white, laminar crystals or crystalline powder; loses ammonia on exposure to air; bitter saline, then acrid taste; soluble in about 10 parts of water, in about 29 parts of alcohol and in about 10 parts of glycerin; dissociates on heating with ammonia and benzoic acid, which volatilize. For details see U.S.P., p. 42.

For *tests for identity*, for *impurities* (heavy metals) and for *assay* see U.S.P., p. 43 and also Part V of this book.

Remarks.—This official is made by treating ammonia water with a molecular quantity of benzoic acid. There must, however, be a slight excess of ammonia, as the acid benzoate is less soluble than the official salt. It occurs in four-sided crystals, soluble in ten parts of water, and is used as a diuretic.

Dose.—1 gramme (15 grains).

AMMONII BROMIDUM—Ammonium Bromide

(Ammon. Brom.)

It contains, when dried to constant weight, at 100°C. not less than 98.5 per cent. of NH_4Br (97.96). Preserve it in well-closed containers.

Summarized Description.

Colorless, hygroscopic, prismatic crystals or white, granular powder; pungent, saline taste; soluble in about 1.3 parts of water and in about 9.7 parts of alcohol; volatilizes on heating. For details see U.S.P., p. 43.

For *tests for identity*, for *impurities* (iodide, bromate, iron, barium, sulphates, heavy metals, non-volatile matter), and for *assay* see U.S.P., p. 43 and also Part V of this book.

Remarks.—This salt is made in several ways: first, by treating the ammonium sulphate with potassium bromide, and precipitating out the potassium sulphate thus formed, by the addition of alcohol; secondly, by treating ferrous bromide with ammonia water, and filtering the resulting ferric hydrate, and concentrating the filtered solution of ammonia bromide. Dr. Pile's process is by treating bromine with ammonia water, as shown in the following equation:

$$6Br + 8NH_3 = 6NH_4Br + N_2.$$

The bromine must be placed in a stone jar, with four times its weight of water, the ammonia gas being added very gradually to the mixture until the solution is free from the odor of bromine. Too much stress cannot be laid on the care required in adding ammonia water, as the rapid addition of ammonia may result in the formation of a very explosive nitrogen bromide (NBr_3).

Ammonium bromide is used as a hypnotic.

Dose.—1 gramme (15 grains).

AMMONII CARBONAS—Ammonium Carbonate

(Ammon. Carb.)

It consists of varying proportions of a mixture of acid ammonium carbonate [NH_4HCO_3 = 79.05] and ammonium carbamate [$NH_4NH_2CO_2$ =78.07], and yields not less than 30 per cent. nor more than 32 per cent. of NH_3. Preserve it in well closed containers in a cool place. For medicinal purposes, use only the translucen portions.

Summarized Description.

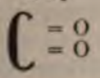
White, hard, striated, translucent masses; ammoniacal odor and taste; exposed to air, loses both ammonia and carbon dioxide, effloresces and falls to a white powder; volatilizes without charring, soluble in about 4 parts of water; decomposed by hot water. For details see U.S.P., p. 44.

For tests *for identity*, for *impurities* (heavy metals, sulphate, thiosulphate, chloride empyreumatic matter), and for *assay* see U.S.P., p. 44 and also Part V of this book.

Ammonium carbonate is not a true carbonate, the formula of which would be $(NH_4)_2CO_3$, analogous to Na_2CO_3. The official salt is the combination of ammonium bicarbonate $(NH_4)HCO_3$ (analogous to $NaHCO_3$), with ammonium carbamate. This carbamate is a complex substance, the derivation of which is here given as a matter of general interest.

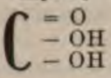
Let us place side by side the graphic formulas of carbon dioxide, carbonic acid, and urea, a constituent of the urine, which has historic interest as the first organic substance that was made synthetically:

Carbon dioxide
CO_2



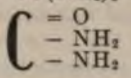
$$\mathrm{C}\begin{cases}=\mathrm{O}\\=\mathrm{O}\end{cases}$$

Carbonic acid
H_2CO_3



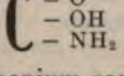
$$\mathrm{C}\begin{cases}=\mathrm{O}\\-\mathrm{OH}\\-\mathrm{OH}\end{cases}$$

Urea
$CO(NH_2)_2$



$$\mathrm{C}\begin{cases}=\mathrm{O}\\-\mathrm{NH_2}\\-\mathrm{NH_2}\end{cases}$$

Carbamic acid is half-way between carbonic acid and urea, its graphic formula being—



$$\mathrm{C}\begin{cases}=\mathrm{O}\\-\mathrm{OH}\\-\mathrm{NH_2}\end{cases}$$

or HNH_2CO_2. Therefore, ammonium carbamate is $NH_4NH_2CO_2$.

This is the first carbonate we have discussed that deviates from the theoretic formula, such as can be developed by the method given on p.

362. We find, however, that there are several other official carbonates that are irregular as to formulas, and among them may be cited the carbonates of magnesium, zinc, and bismuth.

The official ammonium carbonate can be converted into the true carbonate by dissolving in water containing ammonia.

If we take ammonium bicarbonate........... NH_4HCO_3
and add to it ammonia.................... NH_3

we get neutral ammonium carbonate.......$(NH_4)_2CO_3$
Likewise, if we take ammonium carbamate... $NH_4NH_2CO_2$
and add to it water....................... $H_2\quad O$

we get neutral ammonium carbonate....... $NH_4NH_4CO_3$
or $(NH_4)_2CO_3$.

Official ammonium carbonate can also be considered as $(NH_3)_3(CO_2)_2$, H_2O.

Ammonium carbonate is prepared by subliming a mixture of crude ammonium sulphate with calcium carbonate. It is interesting to note that attempts to prepare same by aqueous crystallization have never met with success, hence attempts to restore effloresced ammonium carbonate by crystallization are futile.

Ammonium carbonate is a stimulant of particular value in diseases affecting the pulmonary mucous membrane, and hence it is used in pneumonia.

Dose.—300 milligrammes (5 grains).

SPIRITUS AMMONIÆ AROMATICUS—Aromatic Spirit of Ammonia

(Sp. Ammon. Arom.)

Condensed Recipe.

Ingredients.—Translucent ammonium carbonate, 34 Gm.; ammonia water, 90 mils; oils of lemon, lavender and nutmeg; alcohol, 700 mils; distilled water enough to make 1000 mils.

Manipulation.—Dilute the ammonia water with 140 mils of water, dissolve therein the carbonate and let stand for twelve hours. Dissolve the oils in the alcohol, then add the carbonate solution and enough water to make 1 liter. Let stand twenty-four hours and then filter. For details see U.S.P.

Summarized Description.

Colorless when fresh, yellow when older; ammoniacal odor and taste; sp. gr., 0.900. For details see U.S.P., p. 405.

Remarks.—In making this preparation ammonia water is added to the official ammonium carbonate, and this means adding ammonia to the bicarbonate and water to the carbamate; in other words, the solution of the official carbonate, in water containing ammonia, converts that mixed salt into the true carbonate, as shown above. This ammoniacal solution of the true carbonate is added to an alcoholic solution of the volatile oils of lemon, lavender flowers, and nutmeg. But the conversion of the bicarbonate and carbamate of the official salt into the true carbonate occurs completely only when the official salt is in "translucent pieces," as directed by the pharmacopœia. Translucent means intermediate between transparent and opaque. One cannot see through a translucent substance as one can through a pane of glass, but some light passes through the substance. Ground glass or thin pieces of horn are good examples of translucent substance. Examination of ammonium carbonate will show that it is hard to keep it in translucent pieces, the lumps become covered with white powder, which is wholly ammonium bicarbonate; that is, the carbonate gradually changes into the bicarbonate by the loss of ammonia and the absorption of moisture from the air. So eventually the entire mass of a sample of official carbonate will be converted into the bicarbonate, falling to a powder.

What happens when we try to use such effloresced carbonate—really bicarbonate—in the aromatic spirit? The ammonia water directed by the official process is only sufficient to convert the theoretic quantity of bicarbonate contained in the official salt into normal carbonate, while the balance of the bicarbonate, which would have been carbonate were the salt in translucent pieces, dissolves unchanged. So far, good! but the evil effects come when we begin to add the aqueous solution to the alcoholic solution. The carbonate is soluble in alcohol, the bicarbonate is not, and if the aqueous solution contains any bicarbonate, the latter will be precipitated so soon as its solution is added to the alcoholic liquid.

Aromatic spirit of ammonia, when freshly prepared, is colorless, but on standing it gradually becomes dark, eventually turning to an amber tint. This darkening has been ascribed to some chemical action between the oils which are used and the alkali. The pharmacist should prepare his customer for any change in the color of the two samples of this or any other preparation when a prescription for the same is repeated. In this special case it is better to dispense an aromatic spirit of ammonia which has aged sufficiently to be somewhat colored. At any rate, a pharmacist should never let a customer obtain a preparation of a color different from that of the first sample without calling the customer's attention to the difference in coloration and giving the reason for same.

Dose.—2 mils (30 minims).

AMMONII CHLORIDUM—Ammonium Chloride

(Ammon. Chlor.)

It contains, when dried to constant weight at 100°C., not less than 99.5 per cent. of NH_4Cl (53.50)

Summarized Description.

White, granular powder; cooling saline taste; somewhat hygroscopic; soluble in about 2.6 parts of water, in about 82 parts of alcohol and in about 10 parts of glycerin; volatilizes on heating. For details see U.S.P., p. 45.

For *tests for identity*, for *impurities* (heavy metals, sulphocyanate, non-volatile matter) and for *assay* see U.S.P., p. 45 and also Part V of this book.

Remarks.—This salt is the oldest of the ammonium compounds, and in fact, the word ammonia was derived from its synonym, *sal ammoniac.* Legend tells us sal ammoniac was first prepared in the Lybian desert near the temple of Jupiter Ammon, and for this reason it was called sal ammoniac.

Recent investigators, however, claim that the sal ammoniac of Herodotus and Pliny was nothing but common salt, and that the first reference to ammonium chloride is found in writings of Geber (eighth century), in the Latin translations of which book it is called sal *armoniac.*

Ammonium chloride is made by subliming ammonium sulphate with common salt. According as the apparatus is arranged to collect the vapors in a dome or in a vessel at one side we obtain the ammonium chloride in the form of a cake or in a fine powder. (See Sublimation, p. 108.) Since sublimation is usually carried on in iron vessels, commercial ammonium chloride frequently contains traces of iron. These can be removed by treating the solution with ammonia water and granulating the filtrate. At present a large amount of ammonium chloride is made by subliming a crude chloride, obtained by passing illuminating-gas (p. 450) through hydrochloric instead of sulphuric acid. Commercial sal ammoniac is in the form of white, translucent, tough cakes, about two inches thick, convex on one side and concave on the other, being formed as a crust in the dome of the subliming apparatus. The official ammonium chloride is a white, crystalline powder, permanent in the air, and soluble in three parts of water, but almost insoluble in alcohol. This crystalline powder is obtained usually by granulation.

The ammonium chloride, as just mentioned above, is quite volatile, and its vapors cause red litmus-paper to turn blue, and blue litmus-paper to turn red. Such substances as convert both colors of litmus-paper to the opposite colors are termed *amphoteric*. In the case of the sal ammoniac this phenomenon has been used as the basis of the claim that ammonium compounds are not definite compounds, but merely combinations of ammonia gas with the corresponding acid.

Ammonium chloride is a valuable stimulant and expectorant, and its vapor is frequently used as an inhalant in bronchial troubles, and numberless inhalers have been devised for its administration. In most cases their principle of action is the sucking into the nose or throat of air which has passed through hydrochloric acid and ammonia, and which is thus charged with ammonium chloride.

Dose.—300 milligrammes (5 grains).

Ammonium citrate can be made by treating ammonium carbonate or ammonia water with citric acid. A recipe for *solution of ammonium citrate* is given in the National Formulary.

AMMONII IODIDUM—Ammonium Iodide

(Ammon. Iod.)

It contains, when dried to constant weight at 110°C., not less than 99 per cent. of NH_4I (144.96). Preserve it in small, well-closed containers, protected from light.

Summarized Description.

Minute, colorless, hygroscopic cubical crystals or white granular powder; sharp saline taste; turns yellow to brown on exposure to air, decomposing into ammonia and iodine; soluble in 0.6 part of water, in about 3 parts of alcohol and in about 2 parts of glycerin. For details see U.S.P., p. 45.

For *tests for identity*, for *impurities* (barium, iron, free iodine, heavy metals) and for *assay* see U.S.P., p. 45 and also Part V of this book.

Remarks.—This official is made by treating the ammonium sulphate with potassium iodide, as shown in the following equation:

$$(NH_4)_2SO_4 + 2KI = K_2SO_4 + 2NH_4I.$$

The resulting potassium sulphate is separated from the ammonium iodide by precipitation with alcohol. It might be well here to refer to the ingenuity exercised in attempts by the manufacturing chemist to remove the by-products from the chemical desired. It will be noticed that, whenever possible, the chemist arranges that the by-product be an insoluble salt when the product desired is soluble. This, for instance, is shown in the manufacture of the solution of soda (p. 987). When the product desired is insoluble, then the manufacturer aims to make the by-product a soluble body. This is shown in the manufacture of calcium carbonate (p. 993).

In one case the soluble body is freed from the insoluble body by filtration; in the other case, the insoluble substance is freed from the soluble side-product by washing. But as the formation of an insoluble side-product is sometimes difficult, as was shown in the case of the manufacture of hydrobromic acid, recourse was had, in the Fothergill process, to the sparing solubility of potassium bitartrate, and into this salt was the potassium bromide converted by use of tartaric acid. In hydrobromic acid we have a product which can be separated from the side-product by distillation, and in the commercial process distillation is employed, but in the case of the ammonium iodide none of the schemes of separation just described is applicable, it being impracticable to form an insoluble or sublimable potassium salt, so recourse is had to the solubility of the ammonium iodide in alcohol and the comparative insolubility of potassium sulphate in the same liquid. Hence the aqueous solution of the two salts is concentrated, alcohol is added, and the mixture cooled, and after the potassium sulphate has separated, the hydro-alcoholic solution of ammonium iodide is filtered and rapidly granulated by evaporation on a water-bath.

Ammonium iodide has the form of minute cubic crystals or white granular powder, very rapidly becoming yellowish or yellowish brown, due to the loss of ammonium and the separation of free iodine. So weak is the combination of the ammonium and the iodine that, during the process of evaporation, the iodine becomes liberated, and it is necessary to add ammonia water or, better, ammonium sulphide, from time to time. It is said that ammonium iodide can be preserved in its original white color by hanging down into the bottle from its neck a cheese-cloth bag containing a lump of ammonium carbonate.

Ammonium iodide is used as a resolvent. When dispensed for internal use, the pharmacist should be careful to see that the product is colorless, and if brown, to bleach with ammonium sulphide, as directed in the pharmacopœial definition given above.

Dose.—300 milligrammes (5 grains).

Ammonii nitras (U.S.P. 1890) or *ammonium nitrate* was first made by Glauber (1667) by treating nitric acid with spirit of hartshorn.

It is now usually made by treating ammonium carbonate with nitric acid and crystallizing by evaporation of the solution. It occurs in colorless crystals, soluble in five parts of water, and, like all ammonium compounds, is easily sublimed. It is interesting to note that when exposed to a current of dry ammonia gas its crystals absorb the gas and melt, yielding eventually a crystalline mass containing 25 per cent. of ammonia.

Its chief use is in the formation of *laughing-gas*, N_2O, which is yielded by heating the salt in a retort.

It is interesting to note that if, instead of the nitrate, ammonium nitrite is heated, nitrogen is produced.

Let us put the equations side by side:

$$NH_4NO_3 + \text{heat} = 2H_2O + N_2O,$$
$$NH_4NO_2 + \text{heat} = 2H_2O + N_2.$$

AMMONII SALICYLAS—Ammonium Salicylate

(Ammon. Salicyl.)

It contains, when dried for twenty-four hours in a desiccator over sulphuric acid, not less than 98 per cent. of $NH_4C_7H_5O_3$ or $C_6H_4(OH)COONH_4$ (155.08). Preserve it in well-closed containers, protected from heat and light.

Summarized Description.

Colorless, lustrous, monoclinic prisms or white crystalline powder; saline and bitter, then sweetish taste; soluble in about 1 part of water and in about 2.5 parts of alcohol. For details see U.S.P., p. 46.

For *tests for identity* and for *impurities* (heavy metals) see U.S.P., p. 46 and also Part V of this book.

Remarks.—This official, made by neutralizing ammonia water with salicylic acid and either crystallizing or granulating the solution by evaporation on water-bath, is preferred by some physicians to sodium salicylate.

Dose.—500 milligrammes (8 grains).

AMMONII VALERAS—Ammonium Valerate

(Ammon. Valer.—Ammonium Valerianate)

A compound of ammonium and valeric acid having a somewhat varying composition. Preserve it in well-closed containers.

Summarized Description.

Colorless, deliquescent, quadrangular plates; valerian odor; sharp, sweetish taste; soluble in about 0.3 part of water and in about 0.5 part of alcohol; volatilized on heating. For details see U.S.P., p. 47.

For *tests for identity*, for *impurities* (acetate, heavy metals) and for *assay* see U. S.P., p. 47 and also Part V of this book.

Remarks.—This preparation, which is supposedly $NH_4C_5H_9O_2$ but which is frequently of variable composition, is made by passing dry ammonia gas into monohydrated valerianic (or valeric) acid. In the manufacture of this product it is very important to secure the proper valerianic acid. As noted on p. 671, most of the commercial acid is that containing three molecules of water, and this acid will not yield a satisfactory ammonium salt.

Ammonium valerate occurs in snow-white, four-sided, tabular crystals, having the characteristic odor of valeric acid, and a sharp, sweetish taste. It is used as a sedative in hysteria.

Dose.—500 milligrammes (8 grains).

Ammonium sulphate, $(NH_4)_2SO_4$.—Ammonium sulphate was recognized in the pharmacopœia of 1880, and deserves merely passing notice. As already mentioned, it is made in large quantity from ammoniacal liquor of gas-works, and is the commercial source of ammonia compounds. It can be made by combining ammonia water with sulphuric acid, as explained in Part VII.

Ammonium phosphate, N. F. $(NH_4)_2HPO_4$, was another official salt of the pharmacopœia of 1880. It is made by treating phosphoric acid with ammonia water. A modification of this, the double salt of ammonium and sodium phosphate, NH_4NaHPO_4, is used in chemical work under the name *microcosmic salt* or "*Phosphorsalz.*" This salt, when melted on the loop of platinum, forms a transparent bead, similar to the borax head, and when various metallic salts are melted therein, it assumes characteristic colors.

Another unofficial ammonium compound largely used in chemical work is the so-called *ammonium sulphide*. This is more properly called ammonium sulphydrate, as the reagent used in precipitation in chemical work usually has the composition NH_4HS. However, the composition of this reagent varies, some samples containing a large excess of sulphur, and containing such bodies as $(NH_4)_2S_4$, $(NH_4)_2S_5$, and $(NH_4)_2S_7$.

This test solution is made by saturating ammonia water with hydrogen sulphide gas.

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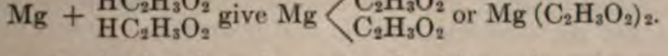
CHAPTER XXVIII

THE ALKALINE EARTH METALS

THE four elements, magnesium, calcium, strontium, and barium, are called alkaline earth metals because their oxides, MgO, CaO, SrO, and BaO, were called alkaline earths by early investigators—alkaline, because they turned red litmus blue, as do the alkalis, and earths, because differing from the alkalis in being found abundantly on the crust of the earth.

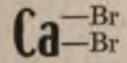
In passing from the alkalis—lithium, sodium, potassium, and ammonium—to the alkaline earths—magnesium, calcium, strontium, and barium—we not only pass into a new analytic group of metals, but also a group the valence of which is different.

The alkalis exhibit the valence I; that is, one atom of an alkali metal replaces one atom hydrogen in an acid, or in combining directly with a negative element, takes up but one atom of that element's free bonds. The alkaline earths are bivalent—can replace two atoms of hydrogen in an acid. Thus, studying the formula of magnesium acetate, since one molecule of acetic acid, $HC_2H_3O_2$, contains only one atom of replaceable hydrogen, two molecules of the acid will be required to furnish the two atoms of hydrogen demanded by one atom of magnesium, and the union will be as follows:



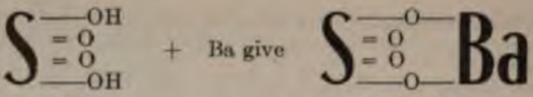
$$Mg + \begin{matrix} HC_2H_3O_2 \\ HC_2H_3O_2 \end{matrix} \text{ give } Mg \Big\langle \begin{matrix} C_2H_3O_2 \\ C_2H_3O_2 \end{matrix} \text{ or } Mg\,(C_2H_3O_2)_2.$$

Again, bromine, having the valence I, and calcium, the valence II, unite as follows:



$$Ca \begin{matrix} -Br \\ -Br \end{matrix} \quad CaBr_2.$$

while sulphuric acid, H_2SO_4, with two replaceable hydrogen atoms, combines with barium like this:



(H_2SO_4) ($BaSO_4$)

MAGNESIUM

Symbol, Mg. Atomic weight, approximately 24.

In the beginning of the eighteenth century a secret remedy was introduced under the name of "magnesia alba," thus differentiating it from the already popular *magnesia nigra*, which is now known as the ore *pyrolusite* (manganese dioxide) (p. 485). A recipe for this magnesia alba was published by Valentinus, of Giessen, in 1707, who obtained it by evaporation of the mother liquor from saltpeter, and lixiviation of the calcined residue.

Before this, magnesium sulphate was described by Nehemiah Grew, having been obtained by him by evaporation of the water of the Epsom spring.

Neither of these writers touched upon the composition of the two compounds, magnesium oxide and magnesium sulphate, and the chemical history of magnesium really begins with the investigation of Black (1755), who proved that magnesium carbonate or magnesite was different from calcium carbonate or limestone. The metal was first isolated by Sir Humphry Davy in 1808, during his classic researches in electrolysis. In 1856 St. Clair Deville devised the chemical method for the isolation given below.

The chief ores of magnesium are the *magnesite*, just mentioned (magnesium carbonate) *dolomite*, a mixed carbonate of magnesium and calcium; *carnallite*, a mixture of potassium and magnesium chloride. (See p. 407.) Aside from these ores, from which the magnesium compounds used in pharmacy are generally derived, there are several magnesium minerals which are of interest other than pharmaceutic. Thus *serpentine*, a green stone, much used in building, is magnesium silicate, as is also *talcum* (*French chalk*), and *meerschaum*, well known as the substance of which the best pipes are made; *asbestos* is a mixed silicate of magnesium and calcium.

The chemical method of isolation of magnesium mentioned above is by heating magnesium chloride with metallic sodium, sodium chloride and calcium fluoride being added to the reacting mixture as a *flux*—that is, as an agent to remove contaminations in the form of a fusible mass. It is now made by the electrolysis of molten magnesium chloride in an atmosphere of hydrogen or nitrogen.

Magnesium is a light, silvery-gray metal, with the specific gravity of 1.75, and usually enters commerce in the form of rods or of thin ribbon. While affected by the air, it does not react with the same as violently as do the alkaline metals. Hence it is unnecessary to keep it under petroleum, as was the case with sodium and potassium. When magnesium is brought into contact with a flame, it becomes incandescent (p. 67) and burns with a brilliant white light, with the formation of magnesium oxide. This property is made use of in the magnesium lantern for theatrical purposes, in which case the magnesium, in the form of ribbons, is allowed to burn at the point of contact of an oxyhydrogen flame. *Flashlight* consists of magnesium in finely powdered form, mixed with powdered potassium chlorate. This mixture, when blown into a flame, ignites instantaneously, producing a brilliant illumination, and is, therefore, largely used for photographic purposes. It should be borne in mind that flash-light is a substance by no means free from danger, and, in fact, should be handled with considerable caution. Several fatal accidents, due to the careless handling of flash-light, are on record, one of the most notable being the killing of three men in the laboratory of Wiley and Wallace, in Philadelphia.

Among the tests for magnesium are: flocculent precipitate of magnesium hydroxide, produced when potassium hydroxide is added to a solution of a magnesium salt, and the white precipitate of magnesium carbonate, produced when the soluble carbonate is added to the solution of magnesium salt. The most characteristic test, however, is the granular precipitate of magnesium ammonium phosphate, produced when a solution of sodium phosphate and ammonia water is added to a solution of magnesium salt. In the manufacture of the salts of magnesium the carbonate is usually employed as a magnesium compound. The following compounds of magnesium and their preparations are official:

Magnesium oxide, 96 per cent. absolute MgO.
Heavy magnesium oxide, 96 per cent. absolute MgO.
Magma of magnesia, 6.5 to 7.5 per cent. absolute $Mg(OH)_2$.
Magnesium carbonate, approximately $(MgCO_3)_4Mg(OH)_2 + 5H_2O$, should contain not less than 39.2 per cent. MgO.
Solution of magnesium citrate. A pharmaceutical.
Magnesium sulphate, 99.5 per cent. absolute $MgSO_4 7H_2O$.

To which might be added:

Ferric hydroxide with magnesium oxide, discussed among the iron compounds.

MAGNESII OXIDUM—Magnesium Oxide

(**Mag. Oxid.**—Magnesia—Calcined Magnesia—Light Magnesia)

It contains, after ignition, not less than 96 per cent. of MgO (40.32) and not more than 2 per cent. of CaO. It contains not more than 10 per cent. of water. Preserve it in well-closed containers.

Summarized Description.

White, very bulky, very fine powder; earthy but not saline taste; absorbs water and carbon dioxide from the air; almost insoluble in water; insoluble in alcohol; soluble in diluted acids. For details see U.S.P., p. 264.

For *tests for identity*, for *impurities* (foreign soluble salts, excess of water of hydration, carbonate, excess of calcium, iron, heavy metals) and for *assay* see U.S.P., p. 264 and also Part V of this book.

MAGNESII OXIDUM PONDEROSUM—Heavy Magnesium Oxide

(**Mag. Oxid. Pond.**—Heavy Magnesia)

It contains, after ignition, not less than 96 per cent. of MgO (40.32), nor more than 2 per cent. of CaO. It contains not more than 10 per cent. of water. Preserve it in well-closed containers.

Summarized Description.

White, dense, very fine powder. For details see U.S.P., p. 264.

For *tests for identity*, for *impurities* and for *assay* see magnesium oxide.

Remarks.—These two magnesias are prepared by the calcination of light and heavy magnesium carbonates respectively, and the carbonate can be made light or heavy as precipitated from cold dilute solutions or from hot concentrated solutions, as already explained in discussion of the formation of light and heavy precipitates (p. 145). Bear in mind that *magnesia is not magnesium.* Magnesium is the metal—the element; magnesia is the oxide of the metal, MgO, not the hydroxide, as was the case with soda and potassa.

The medicinal use of light and heavy magnesia is identical, both being laxative and antacid, the advantage of the heavy magnesia over the light magnesia depending entirely upon its greater density, the average heavy magnesia occupying only about one-quarter the bulk of the light magnesia. This should be remembered in considering the dosage of the two preparations, they being generally employed in domestic practice, and then given by measure rather than by weight. A dessert-spoonful of light magnesia is generally given as the dose, while of the heavy magnesia, a half-teaspoonful to a teaspoonful is usually sufficient. In each case the customer should be directed to administer the substance in a moist condition. Thus, in giving the heavy magnesia, place from one to two teaspoonfuls of water in a tablespoon, and add thereto the teaspoonful of magnesia. The process should never be reversed, as the adding of water to the magnesia gives rise to hard lumps, whereas by the method just given a smooth mixture is obtained.

Under no circumstance should the pharmacist advise placing dry magnesia in the mouth, as the chemical will then adhere to the tongue and roof of the mouth, producing so disagreeable an impression that the victim will always remember the person giving such advice.

The addition of water to magnesia produces magnesium hydroxide by the following reaction:

$$MgO + H_2O = MgO_2H_2 \text{ or } Mg(OH)_2.$$

Dose of both oxides of magnesium, as given by the pharmacopœia. 2 grammes (30 grains).

MAGMA MAGNESIÆ—Magnesia Magma

(**Magma Mag.**—Milk of Magnesia)

Condensed Recipe.

Mix 125 Gm. magnesium carbonate with enough distilled water to make a smooth paste; dissolve 80 Gm. sodium hydroxide in 400 mils of distilled water and add to the magnesia mixture; shake during fifteen minutes, wash by decantation, with distilled water until washings are almost free from alkali (tested with phenolphthalein). Then let the magma settle and pour off the supernatant liquid until the magma measures 1 liter. Preserve in wide-mouth bottles closed with paraffined corks. Flavor with oil of peppermint or oil of anise if desired. Water clarified with magnesium carbonate may be used instead of distilled water. For details see U.S.P., p. 261.

Summarized Description.

Thick, white, liquid mixture; alkaline reaction. For details see U.S.P., p. 262.

For *tests for identity*, for *impurities* (soluble matter) and for *assay* see U.S.P., p. 262 and also Part V of this book.

Remarks.—This new official is a typical *milk of magnesia* and is made by triturating a paste of magnesium carbonate and water with a solution of sodium hydroxide. Hitherto, it has been usually prepared by precipitation; resulting when a solution of magnesium sulphate is mixed with a solution of sodium hydroxide. Magma of magnesia is a very popular antacid and laxative.

Dose.—10 mils (2½ fluidrachms).

MAGNESII CARBONAS—Magnesium Carbonate

(Mag. Carb.)

A mixture of hydrated magnesium carbonate and magnesium hydroxide, corresponding to not less than 39.2 per cent. of MgO (40.32) and not more than 0.8 per cent. of CaO.

Summarized Description.

Light, white, friable masses or bulky white powder; slight earthy taste; permanent in air; practically insoluble in water, which is however made alkaline; insoluble in alcohol; soluble in diluted acids, with effervescence; is calcined by strong heat. For details see U.S.P., p. 262.

For *tests for identity*, for *impurities* (foreign soluble salts, excess of calcium, iron, heavy metals) and for *assay* see U.S.P., p. 263 and also Part V of this book.

Remarks.—It will be noticed that this chemical is one of the four official carbonates not possessing the formula of the true carbonate. (See p. 453.) In all these cases the deviation from the theoretic is not intentional, but is due simply to the fact that the true carbonates are unstable, and the formula given represents, as nearly as possible, the composition of the purest form which this chemical ordinarily assumes.

Magnesium carbonate is made by the double decomposition of magnesium sulphate with sodium carbonate.

According to conditions of chemical actions—temperature and concentration of reacting solutions, treatment after formation, etc.—the finished product can have most varying composition.

Thus, under differing conditions, from solutions of magnesium sulphate and sodium carbonate can be obtained $MgCO_35H_2O$; $MgCO_3$-$2H_2O$; $(MgCO_3)_2Mg(OH)_22H_2O$; $(MgCO_3)_3Mg(OH)_25H_2O$; and $(MgCO_3)_4Mg(OH)_2$, combined with five to eleven molecules of water respectively.

The usual commercial carbonate has the composition $(MgCO_3)_4Mg(OH)_25H_2O$, and this formula was assigned to it by U.S.P. VIII. The present pharmacopœia gives no formula, merely stating that it must represent 39.2 per cent. of magnesium oxide.

As mentioned above, according as the precipitation takes place in a cold diluted solution or in hot concentrated solutions, do we obtain light precipitated carbonate or heavy precipitated carbonate. As far as the carbonate itself is concerned, this is of little importance, but when we consider that the two official forms of magnesia are derived from the light and heavy carbonates respectively, then the question forces itself upon our notice.

The official magnesium carbonate is a light form, the heavy carbonate being of interest merely in the formation of heavy magnesia, and for this purpose manufacturers resort to extraordinary pains to manufacture a dense magnesium carbonate.

Magnesium carbonate is a valuable antacid and a laxative.

Dose.—3 grammes (45 grains).

LIQUOR MAGNESII CITRATIS—Solution of Magnesium Citrate

(Liq. Mag. Cit.)

One hundred mils of the Solution contains magnesium citrate corresponding to not less than 1.5 Gm. of magnesium oxide ($MgO = 40.32$).

Condensed Recipe.

Ingredients.—Magnesium carbonate, 15 Gm.; citric acid, 33 Gm.; syrup, 60 mils; potassium bicarbonate 2.5 Gm.; water, enough to make 350 mils. Oil of lemon as flavor; purified talc, as clarifier.

Manipulation.—Dissolve the acid in 150 mils of hot water and mix with a paste of magnesium carbonate in 100 mils of water. When solution is effected, add the syrup, heat to boiling, add the oil of lemon triturated with the talcum, filter while hot into an appropriate bottle (previously scalded with boiling water) add boiled water enough to make 350 mils, then the potassium bicarbonate, and quickly stopper the bottle. Permission is given to use sodium bicarbonate instead of the potassium salt. For details see U.S.P., p. 249.

For *tests for identity*, for *impurities* (tartaric acid, sulphate, calcium) and for *assay* see U.S.P., p. 249 and also Part V of this book.

Remarks.—This official solution is made by treating the carbonate with citric acid, sweetening and flavoring this with syrup of citric acid and oil of lemon, and bottling with an excess of carbon dioxide formed by addition of potassium bicarbonate. The finished product, dispensed in stout bottles securely wired, is popular under the name of *purgative lemonade.*

This recipe has been criticized because the product does not keep. On standing a few weeks there forms within the tightly corked bottle stringy masses, which not only spoil the appearance, but also destroy the pleasant taste. These masses are none other than microscopic plants, produced by spores introduced into the bottle before filling, and thriving in the weak saccharine solution. The formation of these plants can be completely prevented by the simple precaution of sterilization. If care be taken to scald the bottles before putting in the solution, immersing corks in boiled water before being used, and using only freshly boiled water in preparing the solution and filtering through white paper, *not* the common gray, a product is obtained which, in the writer's experience, has kept perfectly for several months.

Occasionally, even with these precautions, a precipitation occurs in the bottled solution. In such cases, however, the precipitate is dense rather than stringy and is said to be due to the formation of normal citrate containing thirteen molecules of water of hydration ($Mg_3C_6H_5O_7 + 13H_2O$). It is also said that if the ratio between the citric acid and the magnesium carbonate used in the recipe is 25 to 10 (about that of the official recipe) the precipitation is prevented.

Dose.—350 mils (12 fluidounces).

Effervescent magnesium citrate (U.S.P. 1890) is prepared by treating magnesium carbonate with citric acid and with sufficient water to produce the chemical action. The resulting pasty mass is then dried, preferably on a radiator, and then reduced to a powder and mixed with sodium bicarbonate, more citric acid, and sugar. This mixture is then moistened with strong alcohol, and granulated by passing through a coarse sieve, as described on p. 152. The official product must be put in warm, completely dried bottles, which should be sufficiently tightly sealed to prevent access of air.

The effervescent citrate is a very agreeable preparation, for when it is added to water, a refreshing effervescent draught is readily obtained. It is usually administered in tablespoonful doses.

MAGNESII SULPHAS—Magnesium Sulphate

(**Mag. Sulph.**—Epsom Salt)

It contains not less than 48.59 per cent. nor more than 53.45 per cent. of anhydrous magnesium sulphate, corresponding to not less than 99.5 per cent. of the crystallized salt [$MgSO_4 + 7H_2O = 246.50$]. Preserve it in well-closed containers.

Summarized Description.

Small, colorless, prismatic needles or rhombic prisms, cooling, saline, bitter taste; efflorescent; soluble in about 1 part of water; almost insoluble in alcohol. For details see U.S.P., p. 265.

For *tests for identity*, for *impurities* (chloride, heavy metals, arsenic), and for *assay* see U.S.P., p. 265, and also Part V of this book.

Remarks.—In magnesium sulphate—the well-known *Epsom salt*—we have the sulphate of a metal with the valence II.

Taking sulphuric acid, H_2SO_4, as the type, we find that, in each of the sulphates hitherto considered, the two hydrogen atoms in the acid were replaced by two atoms of the metal, since the four alkaline metals are univalent. On the other hand, the four alkaline earth metals, which we are now studying, have the valence II; that is, one atom of these metals can replace two atoms of hydrogen in an acid. The difference in these two groups of metals is best shown in a comparison of their sulphates, as here given.

Sulphates of the alkali metals:

K_2SO_4	Na_2SO_4	Li_2SO_4	$(NH_4)_2SO_4$
Potassium sulphate.	Sodium sulphate.	Lithium sulphate.	Ammonium sulphate.

Sulphates of alkaline earth metals:

$MgSO_4$	$CaSO_4$	$SrSO_4$	$BaSO_4$
Magnesium sulphate.	Calcium sulphate.	Strontium sulphate.	Barium sulphate.

As above mentioned, magnesium sulphate contains seven molecules of water of crystallization. Of these, six molecules are lost by heating the crystals to 110°C., while the seventh molecule requires a heat of at least 200°C. to dry it off. This leads some to consider the linkage between the seventh molecule of water and the rest of the compound as stronger than is the case with the other six, and it has given rise to a supposed distinction in water of crystallization, the comparatively easily removed water being called water of crystalization, while the molecule of water tenaciously holding to the molecule being called water of constitution. This topic has already been touched upon on p. 150.

Magnesium sulphate is made on an enormous scale commercially from the native magnesium minerals, dolomite or magnesite being generally employed. In the case of the first, the dolomite is calcined, whereby we obtain a mixture of the oxides of calcium, magnesium, and iron. The calcined mass is then treated with hydrochloric acid producing the chlorides of the three metals. The filtered solution is then evaporated, and during this process the magnesium chloride dissociates, as shown in the following equation:

$$\begin{array}{rcccccc} & MgCl_2 & + & O & = & MgO & + & Cl_2 \\ \text{or} & MgCl_2 & + & H_2O & = & MgO & + & 2HCl. \end{array}$$

Hence the evaporated mass is a mixture of the chlorides of calcium and of iron, while the magnesium has been converted into sparingly soluble magnesium oxide. The two chlorides just mentioned are readily removed from the magnesium by treatment with water, and the magnesia residue thus freed from the iron and calcium is then treated with sulphuric acid, and the resulting sulphate purified by crystallization. In view of the peculiarity just mentioned regarding the instability of magnesium chloride, it might be here stated that the one way of obtaining a dry magnesium chloride is by the evaporation of a mixed solution of magnesium chloride and ammonium chloride.

Magnesium sulphate is a valuable saline cathartic and is a constituent of many of the most popular purgative waters. The chief objection to its use is the disagreeably bitter taste which the salt possesses, and it might here be stated that this disagreeable taste can be much lessened by administering the solution in an ice-cold condition.

Several fatal accidents have occurred from the substitution of zinc sulphate for magnesium sulphate.

Dose.—15 grammes (4 drachms).

Magnesii sulphas effervescens (U.S.P. VIII), or effervescent magnesium sulphate, is prepared by granulating a mixture of magnesium sulphate, sodium bicarbonate, tartaric and citric acids. It contains 50 per cent. of crystalline sulphate and is used as a purgative in 240-grain doses.

Liquor magnesii sulphatis effervescens (N.F.) is an effervescent draught containing 25 grammes of Epsom salt to the dose of 350 mils. Like solution of magnesium citrate, it is to be dispensed in strong bottles. (See p. 191.)

Sal kissingense factitium (N.F.), or *artificial kissingen salt*, is a mixture of magnesium sulphate, sodium and potassium chlorides and sodium bicarbonate.

Sal kissingense factitium effervescens (N.F.) is the above salt made into effervescent granules with sodium bicarbonate and tartaric and citric acids.

Sal vichyanum factitium (N.F.), or *artificial vichy salt*, is a mixture of magnesium sulphate, sodium chloride and bicarbonate and potassium carbonate.

Sal vichyanum factitium effervescens (N.F.) is the above salt made into effervescent granules with sodium bicarbonate and tartaric and citric acids.

Sal vichyanum factitium effervescens cum lithio (N.F.) contains lithium citrate in addition to the ingredients mentioned above.

TALCUM PURIFICATUM—Purified Talc

(Talc. Purif.)

A purified, native, hydrous magnesium silicate sometimes containing a small amount of aluminum silicate.

Summarized Description.

Very fine, white or grayish-white powder; slippery to touch; odorless and tasteless; insoluble in water. For details, see U.S.P., p. 437.

For *tests for identity*, for *impurities* (soluble substances, iron) see U.S.P., p. 437.

Remarks.—This is talc (*soapstone* or *French chalk*) purified by treatment with hydrochloric acid. It is used as a filtering medium in those cases where precipitated calcium phosphate was directed by the pharmacopœia of 1890, such as in making aromatic waters and some of the syrups.

Magnesii Sulphis (U.S.P. 1890). This former official is made by passing sulphurous acid gas through milk of magnesia (magnesium hydroxide), as shown in the following equation:

$$Mg(OH)_2 + SO_2 = MgSO_3 + H_2O.$$

Magnesium sulphite is used as an antiferment, and given in doses of from 1 to 2 grammes.

CALCIUM

Symbol, Ca. Atomic weight, approximately 40.

This element occurs as carbonate in the well-known minerals, *limestone*, *chalk*, and *marble; gypsum* (or in the exsiccated form, commercial *plaster of Paris*) is calcium sulphate, and the same substance in crystalline form constitutes the beautiful mineral, *alabaster*. *Fluorspar*, the transparent crystals used so much in optics, is a form of calcium fluoride.

The word calcium is derived from the Latin word *calx*, lime, which has been in use since ancient days, its manufacture from mussel-shells being described by Dioscorides, while the caustic effect of burnt lime is mentioned by Pliny. Berzelius and Pontin (1808) obtained calcium amalgam by electrolysis of lime in the presence of mercury, and Davy, in the same year, obtained the free metal in impure form by distilling the mercury from the amalgam.

The metal is now obtained by treating calcium chloride with metallic sodium and zinc, the zinc aiding the sodium in removing the chlorine from the calcium chloride. It is also made by electrolysis.

Calcium is light yellow, ductile, malleable, quite stable in the air, but burning with a brilliant yellowish flame. In the so-called *calcium light*, lime or calcium oxide is employed, this substance burning with a brilliant white light when introduced into an oxyhydrogen flame.

Among the tests for calcium is the precipitate of calcium carbonate, produced when a soluble calcium salt is treated with a solution of an alkaline carbonate. More characteristic, however, is the white precipitate of calcium oxalate, produced in solutions of calcium salts on addition of ammonium oxalate solution. Turning to oxalic acid (p. 605), it will be found that lime is its antidote by reason of this very reaction, calcium compounds converting oxalic acid into the insoluble and harmless calcium oxalate.

In making most of the calcium compounds, the precipitated carbonate is employed.

The pharmacopœia recognizes the following compounds of calcium and their preparations:

Lime. At least 95 per cent. absolute CaO.
Solution of lime. At least $^{14}/_{100}$ of 1 per cent. absolute $Ca(OH)_2$.
Lime liniment. A pharmaceutical.
Crude calcium sulphide. At least 55 per cent. CaS.
Calcium bromide. At least 84 per cent. absolute $CaBr_2$.
Prepared chalk. Elutriated chalk containing at least 97 per cent. $CaCO_3$.
Compound chalk powder, containing 30 per cent. prepared chalk.
Chalk mixture, containing 20 per cent. compound chalk powder.
Precipitated calcium carbonate. At least 98 per cent. absolute $CaCO_3$.
Calcium chloride. At least 75 per cent. $CaCl_2$.
Calcium glycerophosphate. At least 98 per cent. absolute $C_3H_5(OH)_2PO_4Ca$.
Calcium hypophosphite. At least 98 per cent. absolute $Ca(PH_2O_2)$.
Syrup of hypophosphites. A pharmaceutical.
Calcium lactate. At least 98 per cent., $Ca(C_3H_5O_3)_2 + 5H_2O$.
Syrup of calcium lactophosphate. A pharmaceutical.

To which might be added:

Chlorinated lime. Considered among the chlorine compounds.

CALX—Calcium Oxide

Lime **Quicklime**

It contains, when freshly ignited to constant weight with a blast lamp, not less than 95 per cent. of CaO (56.07). It loses not more than 10 per cent. of its weight on ignition. Preserve it in air-tight containers in a dry place.

Summarized Description.

Hard, white, or grayish-white masses or granules, or white powder; caustic; soluble in about 840 parts of water; insoluble in alcohol; soluble in glycerin; slakes when treated with small amount of water; aqueous solution is alkaline. For details see U.S.P., p. 95.

For *tests for identity*, for *impurities* (insoluble and volatile matter, carbonates) and for *assay* see U.S.P., p. 96 and also Part V of this book.

Remarks.—This official represents the commercial product obtained by the calcination of limestone (p. 81). Chemically, it is more or less pure calcium oxide, and it might be said, in passing, that the lime made in northern Ohio usually contains strontium.

When treated with a small quantity of water, considerable heat is evolved, and the lump falls to a fine white powder. This is due to the formation of calcium hydrate by the chemical reaction between the water and the lime, which is expressed by the following equation:

$$CaO + H_2O = Ca(OH)_2.$$

The process is familiar under the name of *slaking lime*, the oxide being called *unslaked lime*, while the hydrate is slaked. In slaking small quantities of lime sometimes required in laboratory work, the heat is generated only in small quantities, so that at first glance it appears that no reaction is going on. The writer recalls one experience, when he rejected a sample of lime because of the difficulty of slaking, but found that, when he had thrown the same into water, a very energetic action would take place when a sufficient quantity was employed. This is particularly noticed in the slaking of small quantities required for making small amounts of solution of soda, and the writer's advice is for the operator to be guided by the eventual crumbling of the lump, instead of expecting an evolution of considerable heat.

Lime is used medicinally internally, when properly diluted with water, as an antacid. (See Lime Water.) When large quantities are applied, especially in the unslaked form, it acts as an escharotic and as a depilatory.

The use of lime in forming mortar in cements is so well known that the fact is here mentioned merely to call attention to that particular form called *Portland cement*. This is a mixture of unslaked lime, sand, and aluminum silicate, and is of value because, when immersed in water, it forms a hard mass resisting the action of water, due to the formation of calcium silicate. For masonry constructions under water it is invaluable.

LIQUOR CALCIS—Solution of Calcium Hydroxide

(**Liq. Calc.**—Lime Water)

An aqueous solution containing not less than 0.14 per cent. of $Ca(OH)_2$ (74.09) at 25°C. Preserve it in well-filled, tightly stoppered bottles.

The percentage of calcium hydroxide varies with the temperature at which the solution is prepared, being about 0.17 per cent. at 15°C., and diminishing as the temperature rises.

Condensed Recipe.

Slake 50 Gm. lime with 1000 mils of distilled water and shake during one-half hour. Let stand, decant supernatant liquid, which is thrown away. Wash residual magma until free from chlorides (testing with silver nitrate solution). Then mix magma with 5000 mils of distilled water, shake, let stand twenty-four hours, shake, let stand until coarser particles have subsided, then pour the still milky mixture into a bottle, which tightly cork. Decant clear liquid as desired. For details see U.S.P.

Summarized Description.

Clear, colorless liquid; alkaline in taste and in reaction; absorbs carbon dioxide from the air; becomes turbid on heating, but clears up on cooling.

For details see U.S.P., p. 239.

For *tests for identity*, for *impurities* (alkalies and alkaline carbonates) and for *assay* see U.S.P., p. 239 and also Part V of this book.

Remarks.—This official is largely sold under the name of *lime water*, and contains about 1/7 of 1 per cent. of calcium hydroxide. It represents a saturated solution of calcium hydroxide in water, and emphasis should be laid on the fact that a saturated solution is not necessarily a highly concentrated one. Another interesting point in connection with lime water is that the calcium hydroxide is more soluble in cold water than it is in hot water; and if a saturated solution prepared with cold water be warmed, it becomes turbid by the precipitation of the excess of lime.

Lime water is a preparation that is made by nearly all druggists, and that, unfortunately, in a careless way. Pharmacopœial lime water is *not* made by throwing a lump of lime into a crock, pouring water on it, and using the same lime for many subsequent crockfuls of water. In preparing lime water the pharmacopœial process should be used, and when once practised, it will be found to be of little less inconvenience than the crude method above described, and a highly superior product is obtained.

In preparing the solution of lime the pharmacopœia directs that the lime be slaked with a certain quantity of water, then mixed with water, and the lime allowed to precipitate; the water is then decanted and poured away. This is done because commercial lime usually contains more or less calcium chloride, which, if permitted to remain in the finished solution, would prove rather irritating. Calcium chloride is very soluble in water, and by macerating the lime with a small amount of water, the chloride will dissolve therein, and can be thus completely removed in the first water, which is thrown away. The calcium hydroxide being sparingly soluble, this first water contains comparatively a small amount of lime, and in this way we rid ourselves of the calcium chloride with comparatively little loss of the calcium hydroxide. On throwing away the water containing the calcium chloride the magma is washed and then it is treated with a large quantity of water and the mixture allowed to stand. The pharmacopœia directs that, after shaking and waiting a long enough time for the coarser particles to subside, the liquid containing the undissolved lime in suspension is transferred to a glass bottle, and that this undissolved lime shall remain in the lime water until dispensed, in order that the solution be kept saturated. In practice, this part of the pharmacopœial requirement is rarely followed, and that in the interest of elegant pharmacy, as the pharmacopœia prohibits the filtration of the product, directing that the clear liquid be decanted when needed. Such procedure is almost sure to yield a more or less cloudy liquid, while most careful pharmacists desire to furnish a lime water which is as clear as crystal. In the writer's experience, half-gallon bottles containing the water with an excess of undissolved lime were kept on hand securely corked, and when the half-gallon dispensing bottle became empty, one of those kept in reserve was filtered, and a perfectly transparent liquid was obtained. The pharmacopœial objection to the use of filter-paper is based on the fact that the fibers of the filter absorb a certain quantity of calcium hydroxide, and, therefore, the first portion passing through the filter is deficient in lime strength. This disadvantage can be easily obviated by throwing away the first ounce or two of the filtered lime water and collecting the remainder in an appropriate container.

Several types of lime water containers have been devised. Most of these consist of a large bottle with syphon arrangement similar to that shown on p. 370, but fitted with a tight cork provided with two holes, through one of which passes the syphon tube and through the other a tube for entrance of air. This tube is connected with a wash bottle containing solution of alkali to absorb the carbon dioxide of the air. In preparing these the use of red rubber tubing should be avoided, as it contains sulphides which react with the alkaline calcium hydroxide to form hydrogen sulphide, frequently producing incompatibilities in the prescriptions in which the lime water is employed.

Solution of lime is a valuable antacid.
Dose.—15 mils (4 fluidrachms).

Syrupus Calcis (U.S.P. VIII) or *syrup of lime* is described at length in Part VII. It is made by boiling together lime, sugar and water. It has been used as an antacid and also as an antidote in oxalic acid poisoning.

Dose.—2 mils (30 minims.)

LINIMENTUM CALCIS—Lime Liniment

This well-known official, *Carron oil*, has been mentioned on p. 265, while the chemistry of the preparation is referred to on p. 667. It suffices here to say that it is an emulsion of linseed oil in a lime soap, and is a valuable remedy for burns and scalds. In fact, the name Carron oil is derived from the Carron Iron Works, where it was at first largely used for burns resulting from molten metal. In case of a severe burn it is applied freely on the injured surface, and it is then covered with pads of absorbent cotton.

CALX CHLORINATA—Chlorinated Lime

This has already been considered on p. 374, under the preparations of chlorine, where it is explained that its entire value is due to chlorine content, the lime being merely the container for the valuable gas.

CALCII SULPHIDUM CRUDUM—Crude Calcium Sulphide

(Calc. Sulphid. Crud.—Calx Sulphurata U.S.P. VIII—Sulphurated Lime)

It contains not less than 55 per cent. of CaS (72.14). Preserve it in well-closed containers.

Summarized Description.

Pale gray or yellowish powder; hydrogen sulphide odor; nauseous alkaline taste; decomposes on exposure to moist air; slightly soluble in cold water; insoluble in alcohol. For details see U.S.P., p. 94.

For *tests for identity*, and for *assay*, see U.S.P., p. 94 and also Part V of this book.

Remarks.—The name of this chemical, "*Calcium Sulphide*," is hardly correct, as it is not pure calcium sulphide, CaS, but a mixture of this with calcium sulphate and carbon. No process of manufacture is given in the present pharmacopœia, but U.S.P. VIII directed that it be prepared by heating together exsiccated calcium sulphate, sulphur, charcoal and starch. This meant the reduction of the sulphate with the carbon of the two other ingredients, similar to the reduction process in the manufacture of sulphurous acid given on p. 402, only it is carried farther in the case of sulphurated lime, the reaction being—

$$CaSO_4 + C_2 = CaS + 2CO_2.$$

However, part of the oxygen grasped by the carbon is taken from the air. Starch was also used in the process, to furnish additional carbon as needed.

In the pharmacopœia of 1880 the chemical was made by heating a mixture of lime and sulphur. This yielded a similarly mixed product, for, as seen by the following reaction,

$$4CaO + S_4 = 3CaS + CaSO_4,$$

there is oxygen to be disposed of, thus giving rise to the sulphate.

Sulphurated lime is used as an alterative in skin diseases. It is indicated in that morbid condition of the system which manifests itself in that form of eruption called boils.

Dose.—60 milligrammes (1 grain).

The so-called calcium sulphide used as a depilatory—for the removal of superfluous hair—is, in truth, calcium sulphydrate, that is, calcium sulphide combined with an extra molecule of hydrogen sulphide. This body is made by passing hydrogen sulphide gas through a thin paste of calcium hydroxide in water—which, by the way, is called *milk of lime*.

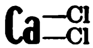
The equation of reaction is:

$$Ca(OH)_2 + 2H_2S = Ca(HS)_2 + 2H_2O.$$

It will be noticed that the five preparations just discussed are considered as compounds of lime rather than as definite calcium salts, such as those we are now ready to take up.

The true salts of calcium are usually prepared by treating the carbonate with the proper acid. Thus are made calcium bromide, $CaBr_2$, and calcium chloride, $CaCl_2$, the graphic formulas of which are good demonstrations of the fact that the calcium is a dyad:

$$Ca\begin{matrix}-Br\\-Br\end{matrix}$$



$$Ca\begin{matrix}-Cl\\-Cl\end{matrix}$$

CALCII BROMIDUM—Calcium Bromide

(Calc. Brom.)

A hydrated form of Calcium Bromide containing not less than 84 per cent. of $CaBr_2$ (199.91). Preserve it in well-closed containers.

Summarized Description.

White, granular, deliquescent salt; sharp, saline taste; soluble in about 0.7 part of water, and in about 1 part of alcohol. For details see U.S.P., p. 89.

For *tests for identity*, for *impurities* (iodides, heavy metals, barium, bromate, chlorides, iron, sulphate, magnesium, alkalies) and for *assay* see U.S.P., p. 89 and also Part V of this book.

Remarks.—This compound can be made by treating calcium carbonate with hydrobromic acid by the following equation:

$$CaCO_3 + 2HBr = CaBr_2 + H_2O + CO_2,$$

or by the double decomposition of calcium hydroxide with ammonium bromide, as shown in the following equation:

$$Ca(OH)_2 + 2NH_4Br = CaBr_2 + 2NH_4OH.$$

In the former case the side product, carbon dioxide, passes off as gas, while in the second reaction the resulting ammonium hydroxide is dissipated during the evaporation of the solution of calcium bromide.

Calcium bromide is used as a hypnotic.

Dose.—1 gramme (15 grains).

Calcium carbonate, $CaCO_3$, is official in two forms.

CRETA PRÆPARATA—Prepared Chalk

(Cret. Præp.—Drop Chalk)

A native form of calcium carbonate freed from most of its impurities by elutriation and containing, when dried to constant weight at 200°C., not less than 97 per cent. of $CaCO_3$ (100.07).

Summarized Description.

White to grayish-white fine powder, or conical drops; permanent in air; almost insoluble in water; insoluble in alcohol; soluble in some diluted acids, with effervescence and decomposition; calcines to calcium oxide. For details see U.S.P., p. 127.

For *tests for identity*, and for *assay* see U.S.P., p. 127 and also Part V of this book.

Remarks.—This represents the native ore, which is mined in large quantities in southwest England; freed from grit by elutriation, and the resulting magma then made into the characteristic cone—prepared chalk—by the process of trochiscation (p. 118).

A characteristic quality of prepared chalk is the stickiness which it possesses, and is preferable to the precipitated chalk in diarrhea mixtures for this very reason, being more likely to adhere to the irritated mucous membrane.

Prepared chalk is a constituent of *compound chalk powder* (p. 291), and this in turn is the main ingredient of *chalk mixture* (p. 257).

Dose.—1 gramme (15 grains).

Whiting is an unofficial form of calcium carbonate, consisting of chalk less carefully washed than prepared chalk. School-crayons formerly represented the same mineral shaped into sticks, but now much of them are made from the sulphate.

CALCII CARBONAS PRÆCIPITATUS—Precipitated Calcium Carbonate

(Calc. Carb. Præc.—Precipitated Chalk)

It contains, when dried to constant weight at 200°C., not less than 98 per cent. of $CaCO_3$ (100.07).

Summarized Description.

Fine, white, micro-crystalline powder; permanent in air; almost insoluble in water; some soluble in water containing ammonium salts or carbon dioxide; insoluble in alcohol; soluble in some diluted acids with effervescence and decomposition; calcined at red heat to calcium oxide. For details see U.S.P., p. 90.

For *tests for identity*, for *impurities* (matter soluble in water and that insoluble in hydrochloric acid) and for *assay* see U.S.P., p. 90 and also Part V of this book.

Remarks.—*Precipitated chalk* is made from prepared chalk by dissolving the same in hydrochloric acid, whereby calcium chloride is produced, and then precipitated by the addition of sodium carbonate to the filtered solution of calcium chloride. The process is enlarged upon on p. 993. It will be noted that the same precipitated chalk is the side-product in the manufacture of the three solutions already described—solution of soda, solution of potassa, and solution of chlorinated soda. The precipitated chalk so obtained, however, is scarcely fit for use, that from the first two products being largely contaminated with alkali, while that from Labarraque's solution smells strongly of chlorine.

The chief use of precipitated chalk is as a tooth-powder, and it is admirably adapted for the purpose in such preparations made by the retail pharmacist. Even better, however, is that form of calcium carbonate obtained by rubbing the soft interior of the cuttlefish bone against a sieve. As already mentioned, precipitated chalk is not as valuable as prepared chalk for diarrhea mixtures.

Dose.—1 gramme (15 grains).

CALCII CHLORIDUM—Calcium Chloride

(Calc. Chlor.)

A hydrated form of Calcium Chloride containing not less than 75 per cent. of $CaCl_2$ (110.99). Preserve it in well-stoppered bottles.

Summarized Description.

White, slightly translucent, hard fragments, or granules or sticks; sharp, saline taste; very deliquescent; soluble in about 0.6 parts of water and in about 8 parts of alcohol; fuses at red heat without decomposition. For details see U.S.P., p. 90.

For *tests for identity*, for *impurities* (iron, aluminium, phosphates, magnesium, alkalies, heavy metals) see U.S.P., p. 91, and also Part V of this book.

This substance, as already mentioned, is prepared by the treatment of calcium carbonate with hydrochloric acid, as shown in the following equation:

$$CaCO_3 + 2HCl = CaCl_2 + CO_2 + H_2O.$$

The solution is evaporated to dryness, and the product comes into the market either in the form of a white, granular powder, or in fused lumps.

Calcium chloride is official because of its value as a desiccating agent, as an absorber of water, it being used very largely in chemical work for this purpose. Thus, in keeping the air in the case of an analytic balance free from moisture, calcium chloride is employed. It is also used as a base for freezing mixtures, for, when combined with snow, it produces the exceedingly low temperature of −48°C.

Dose.—500 milligrammes (8 grains).

A crystalline form of calcium chloride containing one molecule of the salt combined with six molecules of water is known and is sometimes used in medicine.

CALCII GLYCEROPHOSPHAS—Calcium Glycerophosphate

(Calc. Glycerophos.)

The normal calcium salt of glycerophosphoric acid [$C_3H_5(OH)_2PO_4H_2$ = 172.11] containing when dried to constant weight at 130°C., not less than 98 per cent. of $CaC_3H_7O_6P$ or $C_3H_5(OH)_2PO_4Ca$ (210.17). Preserve it in well-closed containers.

Summarized Description.

Fine, white, hygroscopic powder; almost tasteless; soluble in about 50 parts of water; more soluble in cool water than in warm water; insoluble in alcohol. For details see U.S.P., p. 91.

For *tests for identity*, for *impurities* (alcohol-soluble matter, water, phosphates, heavy metals, chlorides, sulphates) and for *assay* see U.S.P., p. 92 and also Part V of this book.

Remarks.—Like sodium glycerophosphate (see p. 436) this new official calcium salt has been very popular as a tonic.

Dose.—250 milligrammes (4 grains).

CALCII HYPOPHOSPHIS—Calcium Hypophosphite

(Calc. Hypophos.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 98 per cent. of $Ca(PH_2O_2)_2$ (170.18). Preserve it in well-closed containers. Caution should be observed in dispensing Calcium Hypophosphite as an explosion is liable to occur when it is triturated or heated with nitrates, chlorates, or other oxidizing agents.

Summarized Description.

Colorless, transparent, monoclinic prisms, or small lustrous scales, or white crystalline powder; nauseous bitter taste; permanent in air; soluble in 6.5 parts of water; insoluble in alcohol; on heating dissociates into phosphine and calcium pyrophosphate. For details see U.S.P., p. 92.

For *tests for identity*, for *impurities* (phosphate, arsenic, heavy metals) and for *assay* see U.S.P., p. 93 and also Part V of this book.

Remarks. This chemical is made by warming a mixture of phosphorus (finely divided, as explained on p. 118), and milk of lime at 40°C., the reaction being

$$3Ca(OH)_2 + 8P + 6H_2O = 3Ca(PH_2O_2)_2 + 2PH_3.$$

The solution of calcium hypophosphite is filtered from the excess of lime and is evaporated at low temperatures until a granular mass results.

The method of manufacture just mentioned is by no means free from danger, as mentioned when discussing the hypophosphites of potassium it possesses, and is preferable to the precipitated chalk in diarrhea mixtures for this very reason, being more likely to adhere to the irritated mucous membrane.

Prepared chalk is a constituent of *compound chalk powder* (p. 291), and this in turn is the main ingredient of *chalk mixture* (p. 257).

Dose.—1 gramme (15 grains).

Whiting is an unofficial form of calcium carbonate, consisting of chalk less carefully washed than prepared chalk. School-crayons formerly represented the same mineral shaped into sticks, but now much of them are made from the sulphate.

CALCII CARBONAS PRÆCIPITATUS—Precipitated Calcium Carbonate

(Calc. Carb. Præc.—Precipitated Chalk)

It contains, when dried to constant weight at 200°C., not less than 98 per cent. of $CaCO_3$ (100.07).

Summarized Description.

Fine, white, micro-crystalline powder; permanent in air; almost insoluble in water; some soluble in water containing ammonium salts or carbon dioxide; insoluble in alcohol; soluble in some diluted acids with effervescence and decomposition; calcined at red heat to calcium oxide. For details see U.S.P., p. 90.

For *tests for identity*, for *impurities* (matter soluble in water and that insoluble in hydrochloric acid) and for *assay* see U.S.P., p. 90 and also Part V of this book.

Remarks.—Precipitated chalk is made from prepared chalk by dissolving the same in hydrochloric acid, whereby calcium chloride is produced, and then precipitated by the addition of sodium carbonate to the filtered solution of calcium chloride. The process is enlarged upon on p. 993. It will be noted that the same precipitated chalk is the side-product in the manufacture of the three solutions already described—solution of soda, solution of potassa, and solution of chlorinated soda. The precipitated chalk so obtained, however, is scarcely fit for use, that from the first two products being largely contaminated with alkali, while that from Labarraque's solution smells strongly of chlorine.

The chief use of precipitated chalk is as a tooth-powder, and it is admirably adapted for the purpose in such preparations made by the retail pharmacist. Even better, however, is that form of calcium carbonate obtained by rubbing the soft interior of the cuttlefish bone against a sieve. As already mentioned, precipitated chalk is not as valuable as prepared chalk for diarrhea mixtures.

Dose.—1 gramme (15 grains).

CALCII CHLORIDUM—Calcium Chloride

(Calc. Chlor.)

A hydrated form of Calcium Chloride containing not less than 75 per cent. of $CaCl_2$ (110.99). Preserve it in well-stoppered bottles.

Summarized Description.

White, slightly translucent, hard fragments, or granules or sticks; sharp, saline taste; very deliquescent; soluble in about 0.6 parts of water and in about 8 parts of alcohol; fuses at red heat without decomposition. For details see U.S.P., p. 90.

For *tests for identity*, for *impurities* (iron, aluminium, phosphates, magnesium, alkalies, heavy metals) see U.S.P., p. 91, and also Part V of this book.

This substance, as already mentioned, is prepared by the treatment of calcium carbonate with hydrochloric acid, as shown in the following equation:

$$CaCO_3 + 2HCl = CaCl_2 + CO_2 + H_2O.$$

The solution is evaporated to dryness, and the product comes into the market either in the form of a white, granular powder, or in fused lumps.

Calcium chloride is official because of its value as a desiccating agent, as an absorber of water, it being used very largely in chemical work for this purpose. Thus, in keeping the air in the case of an analytic balance free from moisture, calcium chloride is employed. It is also used as a base for freezing mixtures, for, when combined with snow, it produces the exceedingly low temperature of −48°C.

Dose.—500 milligrammes (8 grains).

A crystalline form of calcium chloride containing one molecule of the salt combined with six molecules of water is known and is sometimes used in medicine.

CALCII GLYCEROPHOSPHAS—Calcium Glycerophosphate

(Calc. Glycerophos.)

The normal calcium salt of glycerophosphoric acid [$C_3H_5(OH)_2PO_4H_2$ = 172.11] containing when dried to constant weight at 130°C., not less than 98 per cent. of $CaC_3H_7O_6P$ or $C_3H_5(OH)_2PO_4Ca$ (210.17). Preserve it in well-closed containers.

Summarized Description.

Fine, white, hygroscopic powder; almost tasteless; soluble in about 50 parts of water; more soluble in cool water than in warm water; insoluble in alcohol. For details see U.S.P., p. 91.

For *tests for identity*, for *impurities* (alcohol-soluble matter, water, phosphates, heavy metals, chlorides, sulphates) and for *assay* see U.S.P., p. 92 and also Part V of this book.

Remarks.—Like sodium glycerophosphate (see p. 436) this new official calcium salt has been very popular as a tonic.

Dose.—250 milligrammes (4 grains).

CALCII HYPOPHOSPHIS—Calcium Hypophosphite

(Calc. Hypophos.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 98 per cent. of $Ca(PH_2O_2)_2$ (170.18). Preserve it in well-closed containers. Caution should be observed in dispensing Calcium Hypophosphite as an explosion is liable to occur when it is triturated or heated with nitrates, chlorates, or other oxidizing agents.

Summarized Description.

Colorless, transparent, monoclinic prisms, or small lustrous scales, or white crystalline powder; nauseous bitter taste; permanent in air; soluble in 6.5 parts of water; insoluble in alcohol; on heating dissociates into phosphine and calcium pyrophosphate. For details see U.S.P., p. 92.

For *tests for identity*, for *impurities* (phosphate, arsenic, heavy metals) and for *assay* see U.S.P., p. 93 and also Part V of this book.

Remarks. This chemical is made by warming a mixture of phosphorus (finely divided, as explained on p. 118), and milk of lime at 40°C., the reaction being

$$3Ca(OH)_2 + 8P + 6H_2O = 3Ca(PH_2O_2)_2 + 2PH_3.$$

The solution of calcium hypophosphite is filtered from the excess of lime and is evaporated at low temperatures until a granular mass results.

The method of manufacture just mentioned is by no means free from danger, as mentioned when discussing the hypophosphites of potassium and sodium. Not only is the spontaneously inflammable *phosphine* (PH_3) evolved during process of manufacture, but also while granulating the salt. Hence the advice not to heat hypophosphites above 85°C. even on the water-bath.

In this connection it might be well to mention that it frequently happens that the calcium hypophosphite of commerce does not completely dissolve in the amount of water and acid directed for the manufacture of the official syrup of hypophosphites. This is due to the fact that such calcium hypophosphite is not up to the pharmacopœial requirements as to purity, and it is, therefore, good pharmacy always to choose a very reliable make of this salt for hypophosphite preparations. As is the case with all hypophosphites, this salt is supposed to be of value as a nutritive in phthisis. It is a constituent of *syrup of hypophosphites*, U.S.P. (p. 197); while the National Formulary gives recipes, several elixirs and syrups of hypophosphites. (See pp. 201, 207, 208 and 210.)

Dose.—500 milligrammes (8 grains).

CALCII LACTAS—Calcium Lactate

(Calc. Lact.)

The hydrated form of Calcium Lactate [$Ca(C_3H_5O_3)_2 + 5H_2O = 308.23$]. It contains, when dried to constant weight at 120°C., not less than 98 per cent. of $Ca(C_3H_5O_3)_2$ (218.15). Preserve it in well-closed containers.

Summarized Description.

White, granular, efflorescent masses or powder; nearly tasteless; soluble in about 20 parts of water; almost insoluble in alcohol. For details see U.S.P., p. 93.

For *tests for identity*, for *impurities* (heavy metals, magnesium, alkalies,) and for *assay* see U.S.P., p. 94 and also Part V of this book.

Remarks.—This new official is made by treating calcium carbonate with lactic acid. Like syrup of calcium lactophosphate, it is used in rachitis and in scrophulous conditions in children.

Dose.—500 milligrammes (8 grains).

Calcii Phosphas Precipitatus (U.S.P. VIII; N.F. IV) or *precipitated calcium phosphate*, $Ca_3(PO_4)_2$, is obtained from bone-ash, 80 to 85 per cent. of which consists of this chemical.

In preparing it, bones are treated with hydrochloric acid, whereby soluble acid phosphate and calcium chloride are produced, as shown in the following equation:

$$Ca_3(PO_4)_2 \quad + \quad 4HCl \quad = \quad CaH_4(PO_4)_2 \quad + \quad 2CaCl_2,$$

and, on addition of ammonia water to the solution, the phosphate is again formed and precipitates out—

$$CaH_4(PO_4)_2 \quad + \quad 2CaCl_2 \quad + \quad 4NH_3 \quad = \quad Ca_3(PO_4)_2 \quad + \quad 4NH_4Cl.$$

Bone-ash contains some magnesium salts, and the calcium phosphate obtained from this source is apt to contain ammonio-magnesium phosphate. For this reason much of the better grade of calcium phosphate is made by the action of sodium phosphate on calcium chloride in the presence of ammonia. If the reaction takes place in neutral solution, hydrogen calcium phosphate [$CaH_4(PO_4)_2$] is produced.

Because precipitated calcium phosphate is supposed to be practically insoluble in water, this salt was directed by the pharmacopœia of 1890 as the diluent and divider in the making of such preparations as aromatic waters and elixirs and tincture of opium. That the salt is completely insoluble when used for this process is an error, and frequently leads to mischievous results. Waters made with the precipitated phosphate rapidly become stringy, due to microscopic plants, while the alkaloids are rendered partly insoluble, with corresponding decrease in strength of the preparation. For this reason, at the revision of 1900, purified talc was chosen for aromatic waters instead of the phosphate. The precipitated phosphate is used occasionally as a tonic in 15-grain doses.

SYRUPUS CALCII LACTOPHOSPHAS—Syrup of Calcium Lactophosphate

Of this official preparation, which contains 3 per cent. of calcium lactophosphate, full details are on p. 670, so here it suffices to say that the pharmacopœia directs its manufacture by treating calcium carbonate with lactic and phosphoric acids, along with sugar and flavor, and that it is given in 2½-drachm doses.

Calcii Sulphas Exsiccatus (U.S.P. VIII) or *exsiccated calcium sulphate*, $CaSO_4$, represents the native mineral gypsum in exsiccated form, and is commercially known as *plaster of Paris*. Its use in medicine and pharmacy is purely mechanical, and is due to the fact that when combined with water, it forms a paste which quickly settles to a firm, insoluble mass. This makes plaster of Paris of great value in the setting of broken limbs, while its pharmaceutic use in making fast the handles of pestles has already been commented on on p. 115.

Terra alba is a white material used as a filler in cheap candy. Its use is prohibited in most pure food laws. LaWall finds that the substance used under this name is not always the same but that it is sometimes gypsum, sometimes kaolin, or even burnt alum.

STRONTIUM

Symbol, Sr. Atomic weight, approximately, 87.

This element occurs in the minerals *strontianite* (strontium carbonate) and *celestite* (strontium sulphate).

The sulphate is found in considerable quantity in the group of islands in Lake Erie, especially at Put-in-Bay Island.

The carbonate was discovered near Strontian, a village of Scotland, and on being proved different from barium carbonate, was named by Hope, who proved that it contained a new metal by preparing several salts.

The metal was first isolated by Davy in 1808 by electrolysis of the oxide.

Strontium is now made by the electrolysis of strontium chloride.

Strontium is a brassy metal, having the specific gravity of 2.5, and comparatively stable in air. When placed in water, however, it decomposes same in a manner similar to that already explained under Potassium.

The tests for strontium and its compounds are, first, the crimson color which it transmits to a colorless flame, and, secondly, the sparingly soluble sulphate which is formed on adding a soluble alkaline sulphate to a soluble salt of strontium.

Strontium has comparatively little value in pharmacy, its chief use being in pyrotechnics The red flame just described makes the strontium compounds valuable in this direction. Strontium is also used in the sugar industry for the regeneration of molasses.

The pharmacopœia recognizes three salts of strontium—the bromide, the iodide, and the salicylate—the demand for the admission of strontium salts into the United States Pharmacopœia of 1890, being chiefly developed through the advertising efforts of certain firms exploiting such compounds in medicine. The unprejudiced observer finds, however, scarcely sufficient value in strontium compounds to justify official recognition.

STRONTII BROMIDUM—Strontium Bromide

(Stront. Brom.)

It contains not less than 98 per cent. of $SrBr_2 + 6H_2O$ (355.57). Preserve it in well-closed containers.

Summarized Description.

Colorless, hexagonal crystals; bitter, saline taste; deliquescent in moist air, efflorescent in dry air; soluble in about 0.4 part of water; soluble in alcohol. For details see U.S.P., p. 412.

For *tests for identity*, for *impurities* (iodine, bromate, heavy metals, barium) and for *assay* see U.S.P., p. 412 and also Part V of this book.

Remarks.—This compound is prepared by treating the carbonate with hydrobromic acid. It is used as a hypnotic.

Dose.—1 gramme (15 grains).

STRONTII IODIDUM—Strontium Iodide

(Stront. Iod.)

It contains not less than 99 per cent. of $SrI_2 + 6H_2O$ (449.57). Preserve it in small, amber-colored, glass-stoppered bottles, carefully protected from light.

Summarized Description.

Colorless, deliquescent, hexagonal plates, or white, granular powder, or crystalline crusts; bitter saline taste; turns yellow on exposure to light; soluble in about 0.2 part of water and soluble in alcohol; dissociates at red heat into iodine and strontium oxide. For details see U.S.P., p. 412.

For *tests for identity*, for *impurities* (heavy metals, cyanide, chloride, bromide and barium) and for *assay* see U.S.P., p. 413 and also Part V of this book.

Remarks.—This is made by treating strontium carbonate with hydriodic acid. It is used as an alterative.

Dose.—300 milligrammes (5 grains).

STRONTII SALICYLAS—Strontium Salicylate

(Stront. Salicyl.)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of $Sr(C_7H_5O_3)_2 + 2H_2O$ (397.74). Preserve it in well-closed containers, protected from heat and light.

Summarized Description.

White, crystalline powder; somewhat sweet, saline taste; soluble in about 19 parts of water and in about 50 parts of alcohol; chars on heating, leaving strontium carbonate. For details see U.S.P., p. 413.

For *tests for identity*, for *impurities* (heavy metals, barium) and for *assay* see U.S.P., p. 414 and also Part V of this book.

Remarks.—This chemical is made by treating strontium carbonate with salicylic acid.

It is used in rheumatism.

Dose.—1 gramme (15 grains).

BARIUM

Symbol, Ba. Atomic weight, 136.4.

The chief ores of this metal are *heavy spar* (barium sulphate) and *witherite* (barium carbonate). The former ore was called "barote" by Guyton de Morveau (1779), from the Greek word *baros* (heavy), and from this the name of the element was derived.

An amalgam of barium and mercury was first obtained by Berzelius and Pontin in 1808, by electrolysis, but these investigators were unable to isolate the element, this being done by Davy the same year by distilling the mercury from the amalgam.

Barium is now obtained by electrolysis of the fused chloride.

Metallic barium resembles in many ways metallic strontium. It has a specific gravity of 3.75, is a brassy metal, and, like strontium, while stable in air, reacts with water, forming hydrogen and the hydrate of the metal.

The characteristic test for soluble barium compounds is the white precipitate formed by the addition of soluble sulphate. The barium sulphate thus produced is insoluble even in boiling nitric and hydrochloric acids and is one of the most insoluble and infusible substances known. Barium compounds give to a colorless flame a green tint.

No salts of barium are official, but the pharmacopœia of 1890 recognized *barii dioxidum*, BaO_2. This chemical is made by heating barium oxide, BaO, in contact with air. It was made official for the sole purpose of making hydrogen dioxide water by the recipe official in the United States Pharmacopœia of 1890.

The pharmacopœia mentions in the Appendix three compounds of barium used for testing purposes—barium chloride, hydroxide and nitrate—recipes for test solutions of each being given. The purpose of all of these solutions is for the detection of sulphates, they affording the most delicate test for that purpose.

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CHAPTER XXIX

ZINC, MANGANESE, COBALT, AND NICKEL

Referring to the chapter on Analytic Chemistry (p. 879), it will be seen that the alkaline metals, lithium, potassium, sodium, and the radicle ammonium, form the first of the seven groups into which metals are divided in analysis. The alkaline earth metals, magnesium, calcium, strontium, and barium, form the second analytic group—those precipitated from solution by ammonium carbonate and ammonium phosphate.

The third analytic group includes the metals zinc, manganese, cobalt, and nickel; these four elements, along with aluminum, iron, and chromium, being precipitated from alkaline solution by the ammonium sulphide test solution.

The last three metals form the fourth analytic group, the third and fourth groups being differentiated by the fact that the fourth group can be precipitated from acid solution by the addition of ammonia water, while the third group is not precipitated by that reagent.

With the metals considered in this chapter we reach what might be called the commercial metals—that is, those which, by reason of stability, abundance, and general utility, are used largely in the arts as metals. The isolation of these metals from their ores has been practised for many centuries, and the process of extraction now in vogue is largely a modification of ancient methods. The study of the various methods of isolation forms the art called *metallurgy*.

ZINC

Symbol, Zn. Atomic weight, approximately 65.

Zinc occurs as *calamine* (zinc carbonate) and *zinc blend* (zinc sulphide). Calamine is largely mined in the neighborhood of Aix-la-Chapelle, Germany, and it is interesting that in that neighborhood there grows a wild violet which is characterized by the large amount of zinc in its ash, and it is, therefore, given the botanic name of *Viola calaminaris*. In this country zinc is mined in the neighborhood of Joplin, Mo., the ore found there being *sphalerite* (a form of zinc sulphide).

Zinc was early used as a constituent of brassy alloys, the coins of the Roman emperors, Nero and Hadrian, containing it.

For this purpose an ore of zinc was evidently used, Dioscorides and Pliny calling an ore that would turn copper yellow *cadmia*. Ore for similar purposes is called by Arabian writers *climia*, and from this word come such modifications as *calimia* and *lapis calaminaris*. The word zinc is first found in the writings of Basil Valentine and of Paracelsus, but the metal does not seem to have been isolated in Europe until Henkel produced it by a secret process, although Labavius (1597) describes the metal as a peculiar tin from East Indies.

Zinc is made by roasting calamine with charcoal and distilling the resulting zinc. Since calamine is a carbonate; extreme heat will calcine it, with the formation of zinc oxide. If charcoal be present during the calcination, it will act as a reducing agent, removing the oxygen in the form of carbon monoxide and carbon dioxide, by the following reaction:

$$ZnCO_3 + C = Zn + CO + CO_2.$$

This leaves metallic zinc in a more or less impure form, and the metal is, therefore, purified by continuing the heat until the zinc distils over.

If zinc sulphide is the ore employed, it is first roasted in air, when it decomposes into zinc oxide and sulphur dioxide, the latter passing off into the air or being collected in a Gay Lussac tower. The remaining zinc oxide is treated with charcoal, as in the case of calamine.

In technic there are several processes—English, Belgian, and Silesian

—these differing only in the apparatus wherein occurs the reduction of the oxide with charcoal.

Zinc is the first metal which we have considered that is given official recognition; the three metals recognized by the pharmacopœia as uncombined metals being zinc, iron, and mercury.

ZINCUM—Zinc

(Zinc)

It contains not less than 99 per cent. of Zn (65.37).

Summarized Description

Bluish-white metal, in thin sheets, or in granulated pieces, or in thin pencils, or in powder; insoluble in water; soluble in diluted sulphuric or hydrochloric acid, with evolution of hydrogen; malleable at 100° to 150°, brittle at 200°, fuses at 412° to 415°, boils at 940°C. For details see U.S.P., p. 495.

For *tests for identity*, for *impurities* (sulphur, arsenic, antimony, phosphorus) and for *assay* see U.S.P., p. 496 and also Part V of this book.

Remarks.—As will be noted, the pharmacopœia permits the use of zinc in several forms, viz., as sticks, in the form of mossy zinc and sheet zinc, or in the form of a very fine powder.. All these forms are used either for the manufacture of the official zinc salts or for the production of hydrogen. In the latter case zinc is largely used for the purpose of making arsenic tests, and it is essential that the metal so used should be free from arsenic and other impurities found largely in the ordinary commercial zinc. Hence it should be noticed that the pharmacopœia directs a careful test for the presence of arsenic in zinc.

Hydrogen can be produced from zinc in two ways:

Treatment of zinc with a diluted acid:

$$Zn + H_2SO_4 = H_2 + ZnSO_4.$$

Treatment of zinc with a strong alkali:

$$Zn + 2NaOH = H_2 + Na_2ZnO_2.$$

These two reactions will be again mentioned in the chapter on Arsenic (p. 522), so here we need only touch upon that interesting compound, sodium zincate, Na_2ZnO_2. Reference to the tests for zinc salts shows the fact that any soluble zinc salt—say, zinc sulphate—when treated with a solution of an alkali—say, sodium hydroxide—yields a white precipitate which will dissolve on addition of an excess of alkali.

The first stage of this reaction is as follows:

$$ZnSO_4 + 2NaOH = Na_2SO_4 + Zn(OH)_2,$$

the white precipitate being zinc hydroxide.

When more sodium hydroxide is added to this, the precipitate is dissolved by reason of the formation of soluble sodium zincate by the following reaction:

$$Zn(OH)_2 + 2NaOH = Na_2ZnO_2 + 2H_2O.$$

Zincate of sodium, when largely diluted with water, decomposes, sodium hydroxide being produced, and zinc hydroxide being precipitated by the following equation:

$$Na_2ZnO_2 + H_2O = Zn(OH)_2 + 2NaOH.$$

Stress is here laid upon these combinations of zinc salts with alkalis because the same combinations occur when aluminum, manganese, chromium, and, to a lesser extent, iron, are treated with alkalis, this showing that such metals as zinc, aluminum, manganese, chromium, and even iron can act either as positive or negative elements, according as they are associated with elements more positive or negative than themselves.

Zinc is a valuable metal for use in the arts by reason of its power of resistance against the atmospheric change. It is true that when a fresh layer of zinc is exposed to the air, it loses its lustre and becomes covered with a white layer. This layer consists of a mixture of zinc oxide and zinc carbonate, which acts as an admirable protective for the metal underneath, in a way similar to that already explained concerning the protective power of lead sulphate in the lead-chamber process. By reason of the superior stability of zinc, as compared with iron, it is quite largely used for the plating of iron utensils, such zinc-coated iron being called *galvanized iron.*

The tests for zinc and its compounds are: Ammonium sulphide produces a white precipitate of zinc sulphide when brought in contact with a solution of zinc salt. This explains the value of zinc oxide paint. The other chemical largely used as a white pigment is lead carbonate, and this so-called lead paint possesses the objection of blackening when coming in contact with hydrogen sulphide, that reagent thereby producing the black lead sulphide. Therefore, in places where hydrogen sulphide abounds, such as chemical laboratories or water-closets, the zinc paints are preferable.

Any alkaline hydroxide produces a flocculent precipitate of zinc hydroxide with any soluble zinc salt, this precipitate redissolving in excess of alkali. Any soluble carbonate precipitates any zinc salt as a dense white zinc carbonate.

The following salts of zinc and their preparations are official:

Zinc acetate. At least 99.5 per cent. absolute $Zn(C_2H_3O_2)_2 + 2H_2O$.
Precipitated zinc carbonate. Yielding at least 68 per cent. zinc oxide.
Zinc chloride. At least 95 per cent. absolute $ZnCl_2$.
Solution of zinc chloride, containing from 49 to 51 per cent. absolute $ZnCl_2$.
Zinc oxide. At least 99 per cent. absolute ZnO.
Ointment of zinc oxide containing 20 per cent. zinc oxide.
Zinc phenolsulphonate containing 99.5 per cent. absolute $Zn(C_6H_5O_4S)_2 + 8H_2O$.
Zinc stearate. $Zn(C_{18}H_{35}O_2)_2$ admixed with traces of zinc palmitate.
Zinc sulphate. At least 99.5 per cent. absolute $ZnSO_4 + 7H_2O$.
Zinc valerate. At least 99 per cent. absolute $Zn(C_5H_9O_2)_2 + 2H_2O$.

Salts of zinc are usually made from the metal or from the oxide, by treatment with the proper acid. Zinc is a bivalent, even as are alkaline earths (p. 459).

ZINCI ACETAS—Zinc Acetate

(Zinc. Acet.)

It contains not less than 83.16 per cent. nor more than 87.32 per cent. of anhydrous zinc acetate, corresponding to not less than 99.5 per cent. of the crystallized salt [$Zn(C_2H_3O_2)_2 + 2H_2O = 219.45$]. Preserve it in well-closed containers.

Summarized Description.

Soft, white, lustrous six-sided monoclinic plates; faint acetous odor; astringent, metallic taste; efflorescent and partly decomposed when exposed to air; soluble in about 2.3 parts of water and in about 24 parts of alcohol; dissociates on high heat, leaving zinc oxide. For details see U.S.P., p. 489.

For *tests for identity* and for *impurities* (arsenic, heavy metals) see U.S.P., p. 489 and also Part V of this book.

Remarks.—This salt is made by dissolving zinc oxide in acetic acid, as shown in the following equation:

$$ZnO + 2HC_2H_3O_2 = Zn(C_2H_3O_2)_2 + H_2O.$$

Zinc acetate is a mild astringent, of considerable value in the manufacture of eye-washes and gonorrheal injections. For the latter purpose a favorite prescription is one combining lead acetate and zinc sulphate. When the solutions of these two salts are mixed, a double decomposition occurs in the formation of zinc acetate, which remains in solution, and lead sulphate, which precipitates out (p. 951).

Zinc acetate is rarely given internally.

Dose.—125 milligrammes (2 grains).

Zinci Bromidi (U.S.P. VIII) or *zinc bromide*, $ZnBr_2$, is made by either one of two ways: A solution of zinc sulphate is treated with a solution of potassium bromide, the potassium sulphate separated from the solution of zinc bromide by the addition of alcohol (see Ammonium Iodide, p. 456). A better method, however, is by treating bromine placed under a considerable layer of water with granulated zinc, the reaction being as follows:

$$Zn + Br_2 = ZnBr_2.$$

In both cases the salt is obtained from the solution by granulation.

Medical Properties.—Zinc bromide is used as a hypnotic in epilepsy in 2-grain doses.

ZINCI CARBONAS PRÆCIPITATUS—Precipitated Zinc Carbonate

(Zinc. Carb. Præc.)

Basic Zinc Carbonate is a compound of somewhat variable chemical composition, corresponding to not less than 68 per cent. of ZnO (81.37).

Summarized Description.

Impalpable, tasteless, white powder; permanent in air; insoluble in water and in alcohol; soluble in diluted acids with effervescence; soluble in ammonia water and in ammonium carbonate solution; calcines to zinc oxide. For details see U.S.P., p. 490.

For *tests for identity*, for *impurities* (heavy metals, excess of alkali) and for *assay* see U.S.P., p. 491 and also Part V of this book.

Remarks.—It will be noticed in the official definition given above that no chemical formula is assigned this salt, and this is because it is of variable composition.

It, like the official magnesium carbonate and lead carbonate, is a mixture of the true carbonate with the hydrate. Like magnesium carbonate, the proportion of the carbonate to the hydrate depends on conditions of precipitation—on concentration of solutions, temperature, and proportion of the two chemicals used in manufacture.

The official carbonate is made by mixing hot solutions of zinc sulphate with sodium carbonate. If cold diluted solutions of the two salts are mixed, the normal carbonate is produced, but during the reaction considerable carbonic acid is evolved, and the carbonate thus produced dissolves in this carbonated water. Hence the process is wasteful, and in factories recourse is always had to the process of hot precipitation. The normal carbonate, moreover, is unstable, producing, on drying, the official carbonate.

Zinc carbonate is used chiefly externally as a dusting-powder, being mildly astringent.

ZINCI CHLORIDUM—Zinc Chloride

(Zinc. Chlor.)

It contains not less than 95 per cent. of $ZnCl_2$ (136.29). Preserve it in small, glass-stoppered bottles.

Summarized Description.

White, or nearly white granular powder, or porcelain-like masses or pencils; intensely caustic; very deliquescent; soluble in about 0.25 part of water and in about 1 part of acohol; soluble in glycerin; at high heat is partly volatilized and partly decomposed. For details see U.S.P., p. 491.

For *tests for identity*, for *impurities* (excess of oxychloride, heavy metals, ammonia, sulphates) and for *assay* see U.S.P., p. 491 and also Part V of this book.

Remarks.—This salt is made by treating metallic zinc with hydrochloric acid, as shown in the following equation:

$$Zn + 2HCl = ZnCl_2 + H_2.$$

The solution of chloride thus produced is evaporated to dryness and placed in warm dry bottles.

Zinc chloride is used chiefly externally as an antiseptic, disinfectant, and caustic. For the latter purpose it enjoyed considerable repute in cases of cancer, a preparation largely used in France—*paté de Canquoin*—being a pasty mass of flour with which is incorporated zinc chloride.

LIQUOR ZINCI CHLORIDI—Solution of Zinc Chloride

Complete details of the manufacture of this solution, called *Burnett's disinfecting fluid*, including the official recipe, will be given in Part VII, so here we need only mention that it is made by treating zinc with hydrochloric acid, evaporating the solution to dryness, adding before evaporation a small quantity of nitric acid, fusing the mass, and then redissolving it in sufficient cold water to make the official liquid contain about 50 per cent. of zinc chloride. The addition of nitric acid prior to fusing is to insure the removal of traces of iron which invariably contaminate the commercial metallic zinc, and in this preparation the latter is usually employed, instead of the official chemically pure metal. Under the treatment just given the zinc chloride undergoes no change, but the iron chloride will be converted into Fe_2O_3, which is insoluble in water (p. 996).

Zinci Iodidum (U.S.P. VIII) or *zinc iodide*, ZnI_2, is made by combining metallic zinc with iodine, as shown in the following equation:

$$Zn + I_2 = ZnI_2.$$

This can be done by combining the two elements dry and subliming the resulting zinc iodide, or the elements can be digested under water and zinc iodide obtained in crystals by evaporation of the solution.

This salt is used as an alterative.

Dose.—65 milligrammes (1 grain).

ZINCI OXIDUM—Zinc Oxide

(Zinc. Oxid.)

It contains, when freshly ignited, not less than 99 per cent. of ZnO (81.37).

Summarized Description.

Fine, amorphous, white, or yellowish-white powder, free from grit; absorbs carbon dioxide from the air; insoluble in water or in alcohol; soluble in diluted acids without effervescence; soluble in ammonia water and in ammonium carbonate solution; turns yellow on heating. For details see U.S.P., p. 492.

For *tests for identity*, for *impurities* (heavy metals, excess of alkali) and for *assay* see U.S.P., p. 492 and also Part V of this book.

Remarks.—This is prepared by the calcination of pure zinc carbonate. It is important for the pharmacist to understand the distinction between the commercial zinc oxide, which is so largely used, and the form recognized by the pharmacopœia. The commercial form is not made by the calcination of zinc carbonate, but by the roasting of crude metallic zinc in a current of air, whereby the resulting zinc oxide sublimes. This form of zinc oxide is used very largely as a paint, and should never be used by the careful pharmacist in making the official zinc salve.

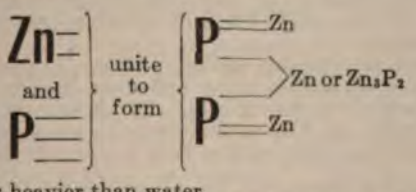
Commercial zinc oxide is of dead white tint, and is more or less gritty, while the official compound has a slightly cream tint. Were it universally employed by the pharmacist for making the official zinc ointment, there would be less complaint about the grittiness of that preparation.

Two synonyms of zinc oxide are worthy of passing notice as relics of the days of alchemy. The chemical is sometimes called *lana philosophica* (philosopher's wool), because the sublimed zinc oxide collects on the condenser in wooly tufts. The other synonym, *nihilum album*, is an interesting illustration of corruption in words in the course of time. The Latin words ninx album (white snow) were coined by some poetic alchemist because of the similarity of sublimed zinc oxide to snowflakes. The term, in being used by another author, was misunderstood and written as "nichts album" (white nothing), which term was found in several books of the seventeenth century. Later some careful student decided the term "nichts album," combining as it did German and Latin, should be placed in correct Latin, and thus the form "nihilum album" (white nothing) originated. It is also called *flores zinci.*

Zinc oxide is used almost entirely externally, and so used it is a mild, healing astringent. It is chiefly applied in the form of the official ointment. (See p. 335.)

Oleatum Zinci (U.S.P. 1890) or *oleate of zinc* is made by sifting zinc through a fine sieve into oleic acid contained in an evaporating dish, and warming until the oxide is dissolved. As already explained under the head of Oleates, this chemical can be considered as a pharmaceutical—as a solution of zinc oleate in a large excess of oleic acid. It is referred to here in order to emphasize the distinction between it and the true *zinc oleate.* While the official oleate of zinc is in the form of a thin, greasy liquid, the definite chemical zinc oleate is a smooth white powder, and is made by mixing solutions of Castile soap and zinc sulphate. It is used in a manner similar to zinc oxide, but by some specialists is preferred to the latter for dusting purposes.

Zinci Phosphidum (U.S.P. 1890) or *zinc phosphide* is made by passing the vapor of phosphorus over powdered zinc in an atmosphere of hydrogen. The performance of this operation, it is needless to say, requires the utmost caution. The zinc is placed in a tube of Bohemian glass, the air having been carefully excluded by passing hydrogen through the tube. The phosphorus is then distilled from the retort, from which the air has also been removed by means of hydrogen, and under such circumstances the two elements combine without danger. Zinc phosphide affords an interesting problem of linking by valence:



It is nearly five times heavier than water.

Zinc phosphide is a nervous stimulant and aphrodisiac, and is administered in doses of from 3 to 8 milligrammes.

ZINCI PHENOLSULPHONAS—Zinc Phenolsulphonate

(Zinc. Phenolsulph.—Zinc Sulphocarbolate)

It contains not less than 73.7 per cent. nor more than 77.4 per cent. of anhydrous zinc phenolsulphonate, corresponding to not less than 99.5 per cent. of the crystallized salt [$(C_6H_4O \cdot SO_3)_2Zn + 8H_2O = 555.72$]. Preserve it in small, well-closed containers.

Summarized Description.

Colorless, efflorescent, rhombic prisms, or tabular crystals or granular powder; astringent metallic taste; turns pink on exposure to light and air; soluble in about 1.6 parts of water and in 1.5 parts of alcohol; clears on heating. For details see U.S.P., p. 492.

For *tests for identity*, for *impurities* (arsenic, heavy metals and sulphate) and for *assay* see U.S.P., p. 492, and also Part V of this book.

Remarks.—This official, also called *zinc sulphocarbolate*, is made by treating barium sulphocarbolate with zinc sulphate, when barium sulphate precipitates, leaving zinc sulphocarbolate in solution. By evaporation of this solution the salt is obtained in crystals. The manufacture of barium sulphocarbolate has already been described on p. 439.

Zinc phenolsulphonate is a useful astringent antiseptic.

Dose.—125 milligrammes (2 grains).

ZINCI STEARAS—Zinc Stearate

(Zinc. Stear.)

A compound of zinc with stearic acid and small, but variable proportions of palmitic acid, containing an amount of zinc corresponding to not less than 13 per cent. nor more than 15.5 per cent. of ZnO.

Summarized Description.

Fine, white, bulky powder; faint characteristic odor; insoluble in water, alcohol or ether; fuses on heating, then burns, leaving residue of zinc oxide. For details see U.S.P., p. 493.

For *tests for identity*, for *impurities* (alkalies, alkaline earths) and for *assay* see U.S.P., p. 493 and also Part V of this book.

Remarks.—This official is a zinc stearate containing traces of zinc palmitate. It is made by treating a solution of sodium or ammonium stearate with a solution of zinc acetate or sulphate, collecting the precipitate, and washing carefully. The sodium stearate is made by treating stearic acid with a hot solution of sodium carbonate.

The resulting white powder is used for dusting purposes, and in the form of ointment.

ZINCI SULPHAS—Zinc Sulphate

(Zinc. Sulph.)

It contains not less than 55.86 per cent. nor more than 58.65 per cent. of anhydrous zinc sulphate, corresponding to not less than 99.5 per cent. of the crystallized salt [$ZnSO_4 + 7H_2O = 287.55$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, efflorescent, rhombic crystals or granular powder; astringent metallic taste; soluble in about 0.6 part of water and about 3 parts of glycerin; insoluble in alcohol; partly dissociated by strong heat. For details see U.S.P., p. 494.

For *tests for identity*, for *impurities* (heavy metals, arsenic, chloride, free acid) and for *assay* see U.S.P., p. 494 and also Part V of this book.

Remarks.—Zinc sulphate (or *white vitriol*) is made on a large scale by roasting the ore, zinc blend (zinc sulphide). The oxygen of the air combines with the heated zinc sulphide, forming zinc sulphate, as shown in the following equation:

$$ZnS + O_4 = ZnSO_4.$$

The sulphate is separated from the extraneous mass of silica and other metals by lixiviation and is then crystallized.

It is also made by treating zinc oxide or metallic zinc with sulphuric acid. Commercial zinc contains iron and other metals, and these are removed from the acid solution by digesting with an excess of zinc, saturating the solution with chlorine gas, and then adding precipitated zinc carbonate. The filtered solution is then evaporated to drive off chlorine and to concentrate to the point at which the sulphate will begin to crystallize.

Zinc sulphate is a very valuable astringent, for which purpose it is given internally in doses of from 1 to 2 grains. In doses five times as great it is an emetic, and is used considerably in evacuating the stomach in cases of poison. For ordinary purposes of emesis it is too irritating, and ipecac is preferable. Externally, zinc sulphate solution is used as an astringent wash, particularly in cases of gonorrhea.

Dose.—As emetic, 1 gramme (15 grains).

ZINCI VALERAS—Zinc Valerate

(Zinc. Valer.—Zinc Valerianate)

It contains not less than 99 per cent. of the crystallized salt [$Zn(C_5H_9O_2)_2 + 2H_2O = 303.55$]. Preserve it in small, well-closed containers.

Summarized Description.

White, pearly scales or white powder; odor of valerian; sweetish, astringent, metallic taste; exposed to air loses valeric acid; soluble in about 70 parts of water and in about 18 parts of alcohol; dissociates at high heat, leaving zinc oxide. For details see U.S.P., p. 495.

For *tests for identity* and for *impurities* (heavy metals, arsenic, acetate, butyrate) see U.S.P., p. 495 and also Part V of this book.

Remarks.—Zinc valerianate is one of the two official salts of valerianic acid (p. 617). It may be made by a double decomposition between sodium valerianate and zinc sulphate.

Zinc valerianate is a valuable nervine and antispasmodic.

Dose.—125 milligrammes (2 grains).

MANGANESE

Symbol, Mn. Atomic weight, 54.6

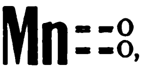
The chief ores of manganese are *pyrolusite* (MnO_2), *braunite* (Mn_2O_3), *hausmannite* (Mn_3O_4), and *manganese spar* ($MnCO_3$).

Manganese affords several official salts. A word as to the origin of its name, which is similar to another element, magnesium, and to the term magnet. In the days of Pliny, at the beginning of the Christian era, three products bearing the name magnesia were known, all coming either from the province of Magnesia, on the borders of Macedonia, or from the country around the city of Magnesia in Asia Minor. Pliny describes all three. One was white (our present magnesium carbonate), one was black and attracted iron (magnetic iron ore), while a third was brown and was used in glass making (manganese dioxide). That form attracting iron was rechristened magnet before the days of Avicenna (A.D. 980–1037), for in his medical writings we find a chapter on magnets, entitled "de Magnete." The distinction in the name manganese and magnesium was not made until the beginning of last century, after both elements had been isolated.

Manganese is obtained by the reduction of the oxide with charcoal at red heat.

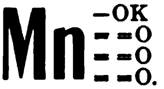
It is a gray-white, hard metal, having the specific gravity of 7.2. It is, like zinc, comparatively stable in air, although it does oxidize in moist air, and more quickly when immersed in water.

Manganese is an element whose valence shows interesting variation. In manganese sulphate, $MnSO_4$, its valence seems to be II; in manganese dioxide, MnO_2, the valence of the metal is IV—



$$\mathrm{Mn}\begin{matrix}=\mathrm{O}\\=\mathrm{O},\end{matrix}$$

while in potassium permanganate, $KMnO_4$, manganese shows the valence VII; the graphic formula of the compound being—



$$\mathrm{Mn}\begin{matrix}-\mathrm{OK}\\=\mathrm{O}\\=\mathrm{O}\\=\mathrm{O}.\end{matrix}$$

Manganese, like zinc, seems to occupy a position between the non-metallic and the metallic elements. It has been shown that when zinc is combined with strong alkalis, zincates are formed, the zinc hydroxide in that case acting as an acid. Still more striking is the case with manganese oxides, particularly those showing the valence VI and VII, permanganic acid, $HMnO_4$, being as distinctly acid as is perchloric acid ($HClO_4$). Yet the manganese with lower valence has basic properties, and when the metal is treated with acid, it yields a manganese salt in which the element shows the valence II.

Tests.—Manganese is interesting to the chemist as affording a large variety of very beautiful tests. When a soluble salt of manganese is treated with ammonium sulphide solution, a flesh-colored precipitate of manganese sulphide is produced. This precipitate is notable as the only flesh-colored sulphide. If a trace of manganese salt is added to a borax bead (see p. 861), a beautiful amethyst color is transmitted to the same. If any manganese salt is fused with a mixture of potassium nitrate and sodium carbonate on a piece of platinum foil, green sodium or potassium manganate is formed, as shown in the following typical equation:

$$MnO_2 + Na_2CO_3 + KNO_3 = KNO_2 + CO_2 + Na_2MnO_4.$$

If this green manganate be boiled with water, a pink solution of the permanganate is formed by the following reaction:

$$3Na_2MnO_4 + 2H_2O = 2NaMnO_4 + MnO_2 + 4NaOH.$$

Crum's test also exhibits the same purple color, due to permanganic acid. It is as follows: if a manganese salt is treated with plumbic oxide and nitric acid, permanganic acid is formed, as shown in the following equation:

$$2MnSO_4 + 5PbO_2 + 6HNO_3 = 2HMnO_4 + 2PbSO_4 + 3Pb(NO_3)_2 + 2H_2O.$$

The same reaction occurs if red lead or if litharge is used instead of plumbic oxide.

The only manganese compounds that are official in the present pharmacopœia are precipitated manganese dioxide and potassium permanganate.

MANGANI DIOXIDUM PRÆCIPITATUM—Precipitated Manganese Dioxide

(Mangan. Diox. Præc.)

It consists chiefly of manganese dioxide [MnO_2 = 86.93] with small amounts of other oxides of manganese, corresponding to not less than 80 per cent. of MnO_2.

Summarized Description.

Heavy, very fine, black powder; insoluble in water and in alcohol; heated with hydrochloric acid, yields chlorine and manganous chloride; at red heat dissociates into oxygen and manganese oxide, Mn_3O_4. For details see U.S.P., p. 266.

For *tests for identity*, for *impurities* (insoluble substances) and for *assay* see U.S.P., p. 266 and also Part V of this book.

Remarks.—This chemical replaces the crude ground ore, pyrolusite, the form of manganese dioxide that was formerly official and is made by precipitating manganous sulphate with ammonia water in the presence of hydrogen dioxide solution. Were manganous sulphate precipitated with ammonia water alone, manganous oxide (MnO) would result; hence the use of the oxidizing agent, hydrogen dioxide.

Precipitated manganese dioxide is used for anemia, particularly that form which comes from female complaints. It is administered preferably by filling capsules with the prescribed amount of the binoxide in fine powder.

Dose.—250 milligrammes (4 grains).

Mangani Hypophophis (U.S.P. VIII; N.F. IV) or *manganese hypophosphite* $Mn(PH_2O_2)_2 + H_2O$, is made by mixing a solution of manganese oxalate with a solution of calcium hypophosphite and evaporating the filtrate on a water-bath to a granular powder.

It is a constituent of *compound syrup of hypophosphites*, N.F., and is used as a tonic, in 3-grain doses.

Mangani Sulphas (U.S.P. VIII; N.F. IV) or *manganese sulphate*, $MnSO_4 + 4H_2O$, is made by treating binoxide of manganese with carbon at red heat, whereby it is reduced to manganous oxide, MnO, as shown in the following equation:

$$2MnO_2 + C = CO_2 + 2MnO.$$

The manganous oxide is made into paste with sulphuric acid and heated to redness, when manganese sulphate is formed, as shown in the following equation:

$$MnO + H_2SO_4 = H_2O + MnSO_4,$$

and goes into solution and is purified by crystallization.

Manganese sulphate is used as a tonic, similar to the iron preparation, and is also used for gout. Its dose is 3 grains.

POTASSII PERMANGANAS—Potassium Permanganate

This salt has been considered under the potassium compounds (see p. 423), so here we need only again call attention to the synonym, *mineral chameleon*, it being so called because of the changes in tint which the permanganate exhibits under treatment with various reagents.

COBALT AND NICKEL

As neither of these metals, nor any of their compounds, is recognized by the pharmacopœia, they can be briefly considered together.

Cobalt, so called from the German *Kobold*, because the miners working in cobalt ores found the same difficult to extract, and attributed this difficulty to the influence of the kobolds, mischievous imps supposed to inhabit mines, occurs in the form of a silvery metal, but little used in the arts. Of its compounds, the silicate is of a striking blue color, and is used in painting and decorating under the name of *smalt;* the chloride, $CoCl_2$, occurs in the form of pink crystals, which comparatively easily effloresce and in so doing will change to a blue tint. For this reason the solution of cobalt chloride has been suggested for *invisible ink* or *sympathetic ink*, the writing appearing practically colorless until heated, when the effloresced salt develops itself in blue tracery. It is also used in the manufacture of cheap paper barometers, consisting of bibulous paper dipped into a solution of cobalt chloride and dried. In moist weather this paper appears to be pink, whereas on drying it becomes blue through the efflorescence of the salt.

Metallic nickel, on the other hand, is very largely used. It is of value for cooking utensils, although for this purpose it is somewhat costly, while the use of nickel coins is so extended as to require no additional comment. The coating of utensils with the metal by electric deposition (*nickel-plating*) is also well known, nickel being used in such cases because it does not easily tarnish.

A valuable alloy of nickel is *German silver*. This consists of 50 per cent. of copper and 25 per cent. each of zinc and of nickel. This alloy possesses a silvery tint, and was formerly largely used as the metallic trimming of glass show-cases.

German silver is the first alloy to which we have referred, and it might be here stated that by an *alloy* we mean a solution of several metals with each other while in a fused state. Such alloys frequently possess valuable properties not shown by their constituents, and many alloys of great value will be discussed on later pages.

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CHAPTER XXX

ALUMINUM, CERIUM, CHROMIUM AND URANIUM

In the last chapter (p. 478) it was stated that the third and fourth groups into which the metals are divided in analytic chemistry include all those elements precipitated from alkaline solution by ammonium sulphide.

It was also learned that the third group were those elements whose hydroxides redissolved in excess of ammonium hydroxide; while the hydroxides of the fourth group, aluminum, iron, cerium, and chromium, did not dissolve in ammonia water. These four metals form, even as did the metals discussed in the last chapter, a group that should be included in one chapter. Since, however, the compounds of iron used in medicine are so numerous and valuable, it is deemed best to consider these in a special chapter, leaving aluminum, cerium, and chromium to be discussed in this chapter.

ALUMINUM

Symbol, Al. Atomic weight, approximately 27

Aluminum is one of the most widely distributed of metals, being found in the form of silicate in *clay*, which is one of the most abundant constituents of the earth's crust. A rare and valuable form of the silicate is sodio-aluminum sulphosilicate, the precious mineral, *lapis lazuli*, while among the oxides of aluminum are found several of the most valuable precious stones, such as *ruby* (which, next to diamond, is the hardest of minerals) and *sapphire*. The color of the ruby is due to a trace of chromium, while the sapphire is tinted with cobalt. *Emerald* is a silicate of aluminum and beryllium, with a trace of chromium sesquioxide (Cr_2O_3). *Emery* is a native granular form of aluminum oxide.

While the salts of aluminum, especially alum, have been known from ancient times, the metal was first isolated by Friedrich Wöhler, in 1827, by heating aluminum chloride with metallic potassium in a well-closed crucible.

Wöhler soon found he could obtain the same results by the use of the cheaper metal, sodium. Ever since its isolation by Wöhler, efforts have been made to devise a cheap process of manufacture, since its lightness, toughness, and, above all, its disinclination to oxidize—to rust, as iron does—gave promise of its great value in the arts.

Metallic potassium and sodium are costly metals; hence aluminum so separated could never compete, in price, with iron. Experiments in this direction, however, especially those performed under the patronage of Louis Napoleon, while emperor, led to the methods of extraction of the metals sodium and potassium, devised by St. Clair Deville, and a marked reduction in the price of these metals.

Aluminum, one of the most abundant of elements, found in the very rocks and clay beneath our feet, is also one of the most difficult to isolate, and it was not until 1886—over half a century after its first isolation by Wöhler—that a cheap method of obtaining the metal was devised and that in the same year (1886) by an American, C. M. Hall and a Frenchman, P. L. V. Heroult. This method is by electrolysis.

Already, on p. 352, we learned that molten salt, when acted upon by an electric current, is so decomposed that the positive element, sodium, goes to the negative pole, while the negative, chlorine, goes to the positive pole, of the battery. This process Hall and Heroult applied to the separation of aluminum from its oxide, emery, and that on a large scale. The process operates on the same principle as an electric arc-light, which is produced by passing a powerful current of electricity through carbon rods representing the positive and negative poles of the battery or dynamo. In the Hall and the Heroult processes a powerful current is run through two bundles of carbon rods several feet long, plunged in a mixture of cryolite and aluminum oxide. The great heat produces a fusion of the mixture and the oxide is then decomposed by the current into the metal. Extra aluminum oxide is added from time to time to make up for that removed as the metal, thus making the process practically continuous. These processes have revolutionized the aluminum industry by bringing the price of the metal to a figure permitting its general use. To Americans the Hall discovery should be a matter of peculiar satisfaction, inasmuch as through it the center of aluminum production was shifted from Germany and Switzerland to America.

The following table, as to reduction in price of aluminum, can be best understood if one remembers that a kilo is 2⅕ pounds and a franc is 20 cents; that the decrease in market price between 1855 and 1856 was due to the introduction of the St. Clair Deville process for making cheap sodium; while the fall in price between 1886 and 1890 was due to the introduction of the Hall process.

The other reductions are in natural sequence to the gradual improvements to these two important processes.

MARKET PRICE PER KILOGRAMME OF ALUMINUM

1855—1250 francs.
1856— 375 francs.
1857— 300 francs.
1886—125 francs.
1890— 19 francs.
1891—6 francs.
1895—4 francs.
1898—2.70 francs.
1911—2.40 francs.

ALUMINUM PRODUCTION (AMOUNTS IN KILOS)

Year	United States, England and France		Germany and Switzerland	
1885	3000		10,292	
	United States	England	France	Switzerland
1890	27,000	70,000	37,000	40,538
1891	1,800,000	300,000	500,000	800,000
1898	2,358,000	300,000	500,000	800,000

To this might be added that while the world's output in 1885 was 13,292 kilos, in 1911 it was 18,500,000 kilos.

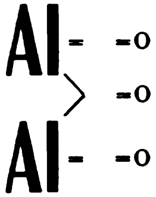
Aluminum is bright, silvery metal, having the specific gravity of 2.7. It is not easily oxidized, and on account of its comparative toughness and great lightness it was expected to play an important rôle in our metallic industries. Enthusiasts even predicted the eventual substitution of aluminum for iron in much structural work. Experience, however, has not substantiated the claims of the friends of aluminum, it being found that the tensile strength of aluminum was quite low. When warmed, it becomes decidedly brittle. It was also hoped that aluminum would be of considerable service in chemical utensils where platinum must now be used, such as in distillations. This, however, was not borne out by facts. Therefore the chief use of aluminum at the present time is for trinkets and ornaments, and, to a certain extent, for cooking utensils, its lightness rendering them far preferable to those made of iron. It is also a constituent of many valuable alloys, such as aluminum bronze, while almost all fine analytic balances have beams of aluminum.

Magnalium is an alloy of aluminum with 2 to 10 per cent. of magnesium, which is very light and also permanent. It is used in aeroplanes.

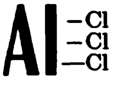
Thermite is a mixture of aluminum oxide and metallic iron, which when heated by burning magnesium, react to form ferric oxide and iron with evolution of a great amount of heat, even as high as 3000°C. It is largely used for welding purposes.

Tests.—The tests for aluminum are, first of all, the white precipitate obtained by treating a soluble aluminum salt with ammonium sulphide, the precipitate in this case, however, not being aluminum sulphide, but aluminum hydroxide. A similar precipitate of the flocculent hydroxide is obtained by treating an aluminum salt with any soluble hydroxide. The behavior of this hydroxide with the reagent, however, differs if sodium or potassium hydroxide is used, on the one hand, or ammonium hydroxide, on the other, the precipitate redissolving with an excess of potassium or sodium hydroxide, with the formation of the aluminates of sodium and potassium, $Al(ONa)_3$ or $Al(OK)_3$. The composition of these aluminates is discussed in the chapter on Sodium (p. 433). On the other hand, aluminum hydroxide does not redissolve in an excess of ammonia water.

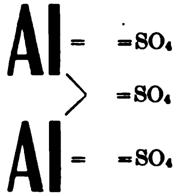
Aluminum is the first metal we have studied having the valence III; hence it is well to consider its combinations. One atom replaces three atoms of hydrogen in an acid, as shown by the graphic formulas given below:



Al_2O_3
Aluminum
oxide.



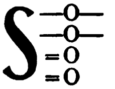
$AlCl_3$
Aluminum
chloride.



$Al_2(SO_4)_3$

Aluminum sulphate.

It will be noticed in the graphic formula of aluminum sulphate given above that the SO_4 group is represented as attaching itself to the aluminum atom with two bonds. That is, if two atoms of hydrogen are removed from H_2SO_4, we have a radicle, SO_4, with two free bonds, viz.:



As these two free bonds act exactly as any other free bonds, the SO_4 group in formula-writing can be considered exactly as we consider an oxygen atom with its two bonds.

It should be stated in passing that many modern chemists think that all aluminum compounds contain two atoms of that element exhibiting the valence VI, and that the formula of aluminum chloride is not $AlCl_3$, given above, but Al_2Cl_6. This idea is based on the molecular weight estimations, for while $AlCl_3$ would mean molecular weight 133.5, the estimations give figures much nearer 267. The double formula, Al_2Cl_6, is explained as is the formula Fe_2Cl_6, which will be considered in the next chapter (p. 503).

The following compounds of aluminum are official:

Alum. Either 99.5 per cent. absolute $AlK(SO_4)_2 + 12H_2O$ or 99.5 per cent. $AlNH_4(SO_4)_2 + 12H_2O$.

Exsiccated alum. Either 98 per cent. absolute $AlK(SO_4)_2$ or 98 per cent. absolute $AlNH_4(SO_4)_2$.

Aluminum hydroxide. (No purity rubric.) $Al(OH)_3$.

ALUMEN—Alum

(Alum.)

It contains not less than 99.5 per cent. of $AlNH_4(SO_4)_2 + 12H_2O$ (453.47), or of $AlK(SO_4)_2 + 12H_2O$ (474.53), the label of the container must indicate whether Ammonium or Potassium Alum.

Summarized Description.

Both forms, in large colorless crystals, in crystalline fragments or as white powder; sweetish, strongly astringent taste; potassium alum is soluble in about 7.2 parts of water, insoluble in alcohol, quite soluble in glycerin; ammonium alum, somewhat less soluble in water then is the potassium compound. For details see U.S.P., p. 39.

For *tests for identity*, for *impurities* (insoluble matter, heavy metals, arsenic, iron) and for *assay* see U.S.P., p. 40 and also Part V of this book.

Remarks.—It should be noted that the present pharmacopœia makes an innovation by recognizing under the name "alumen" either potassa alum, or ammonia alum; the only specification being that each shall be sold under its own name. As to potassa alum, sometimes its formula is written $K_2Al_2(SO_4)_4 + 24H_2O$, while other authorities including the pharmacopœia give it as $KAl(SO_4)_2 + 12H_2O$.

At first glance, the symbolic formula, $K_2Al_2(SO_4)_4 + 24H_2O$, seems exceedingly complicated, but viewed in the light of the synonym—aluminum and potassium sulphate—it becomes simplified. What is aluminum sulphate? We have just learned above that it is $Al_2(SO_4)_3$. And potassium sulphate? This is derived from sulphuric acid, H_2SO_4, by replacing its two hydrogen atoms with two atoms of the univalent element, potassium:

Hence, K_2SO_4,
If we add to this aluminum sulphate, $Al_2(SO_4)_3$,

We get $Al_2K_2(SO_4)_4$,

and if we crystallize this with 24 molecules of water of crystallization, we have the formula $K_2Al_2(SO_4)_4 + 24H_2O$.

The reason that this is not written $Al_2(SO_4)_3K_2SO_4 + 24H_2O$ is because the union between the sulphate of aluminum and potassium is stronger than a mere physical mixture. While not fully proved, we believe that there exists between the two salts a chemical relationship, somewhat akin to that between a salt and its water of crystallization.

Ammonia alum was the "alumen" of the pharmacopœia of 1870, but was replaced in the pharmacopœia of 1880 by the potassa alum. Its re-introduction at this time is because it is cheaper than potassa alum, especially now when potassium compounds are so scarce.

Let us compare the formula of these two alums, representing them as broken into the sulphates of the two metals:

Potassium alum is......... $K_2SO_4Al_2(SO_4)_3 + 24H_2O$.
Ammonium alum is..... $(NH_4)_2SO_4Al_2(SO_4)_3 + 24H_2O$.

The only difference between these two is that in one we have potassium sulphate; in the other, we find ammonium sulphate, each being combined with aluminum sulphate and with 24 molecules of water of crystallization.

When we closely consider the two formulas just given, we find that each represents one molecule of the sulphate of a univalent element, one molecule of a sulphate of a trivalent element, and 24 molecules of water of crystallization. We have seen that the univalent element or radicle can be changed; for in the two alums just mentioned one contained potassium sulphate, the other ammonium sulphate. In like manner we can make a sodium alum of the formula $Na_2SO_4Al_2(SO_4)_3 + 24H_2O$. We have changed the univalent element or radicle three times. Can we thus change the trivalent element? Most assuredly, replacing aluminum by the trivalent elements, iron, manganese, or chromium, getting such compounds as:

$K_2\ SO_4\ Al_2\ (SO_4)_3 + 24H_2O$..........	Potassium alum.
$K_2\ SO_4\ Fe_2\ (SO_4)_3 + 24H_2O$..........	" ferric alum.
$K_2\ SO_4\ Mn_2\ (SO_4)_3 + 24H_2O$..........	" manganese alum.
$K_2\ SO_4\ Cr_2\ (SO_4)_3 + 24H_2O$..........	" chromium alum.
$(NH_4)_2\ SO_4\ Al_2\ (SO_4)_3 + 24H_2O$..........	Ammonium alum.
$(NH_4)_2\ SO_4\ Fe_2\ (SO_4)_3 + 24H_2O$..........	" ferric alum.

We see how many alums can be produced; hence the only general definition of an alum that can be given is that mentioned above: "the combination of one molecule of the sulphate of a univalent element or radicle, with one molecule of the sulphate of a trivalent element or radicle, and with 24 molecules of water of crystallization." Not only do all alums crystallize with the same proportion of water, but also their crystal shapes are the same—in other words, they are *isomorphous*.

Alum has been made for centuries from certain ores of aluminum, particularly alum shale. This is a form of clay containing iron pyrites (FeS_2), and on letting the ore stand exposed to the elements for one to two years, the ferrous sulphide is changed to ferrous sulphate, ferric subsulphate, and free sulphuric acid, and the latter in turn reacts with the clay (aluminum silicate) to form aluminum sulphate. Roasting the ore after standing effects the liberation of more sulphuric acid from the iron sulphates, and the roasted mass on lixiviation yields a solution of aluminum sulphate contaminated with more or less iron. Various methods are employed in removing the iron, such as long standing of the solution exposed to the air, when the iron precipitates as ferric oxide; placing pieces of iron in the solution, which converts all the dissolved iron into ferrous sulphate, which is separated from the aluminum sulphate by fractional crystallization.

The concentrated and pure aluminum sulphate solution is then mixed with potassium (or ammonium) chloride or sulphate, and at the proper degree of concentration crystals of alum begin to separate.

Potassium chloride is used because more abundant than potassium sulphate, and when mixed with aluminum sulphate solution, yields a double sulphate of potassium and aluminum, as shown in the following equation:

$$4Al_2(SO_4)_3 + 6KCl = 3K_2Al_2(SO_4)_4 + Al_2Cl_6.$$

Alum is also made on a large scale by treating the aluminum hydroxide, which is a side-product in the cryolite process (p. 433), with sulphuric acid. Alum occurs in large crystals soluble in 9 parts of water and freely soluble in glycerin. It is a curious fact that from a saturated aqueous solution, the alum crystallizes when glycerin is added and likewise crystallization occurs when water is added to a saturated glycerinic solution.

Alum is a valuable astringent, either internally or else externally in the form of a wash.

Dose.—500 milligrammes (8 grains).

ALUMEN EXSICCATUM—Exsiccated Alum

Recipe and details of manufacture in Part VII.

Remarks.—This official is obtained by the exsiccation of crystallized alum, 100 parts of the crystal yielding 55 parts of the dried alum. (See p. 974.)

Exsiccated alum is used as a mild escharotic under the name of *burnt alum*, being particularly efficacious for the removal of that form of morbid growth developing in an open sore called proud flesh. It is very rarely given internally.

ALUMINI HYDROXIDUM—Aluminum Hydroxide

(Alum. Hydrox.)

A compound consisting principally of aluminum hydroxide $[Al(OH)_3 = 78.12]$.

Condensed Recipe.

Dissolve 100 Gm. alum in 1 liter of water and filter; dissolve 45 Gm. monohydrated sodium carbonate in 1 liter of water and filter. Bring both to boiling, pour the soda solution into the alum solution, add more boiling water to the mixture; wash precipitate by decantation until free from sulphate, then dry at 40°C. For details see U.S.P.

Summarized Description.

White, bulky, amorphous powder; insoluble in water and alcohol; soluble in some diluted acids and in fixed alkaline hydroxides; loses 34 per cent. of its weight at red heat. For details see U.S.P., p. 42.

For *tests for identity*, for *impurities* (alkali salts, heavy metals, arsenic) see U.S.P., p. 42.

Remarks.—Aluminum hydroxide is made by adding a solution of alum to a solution of sodium carbonate. This may at first produce aluminum carbonate, but if such is the case, it is only for an instant, the carbonate decomposing with the evolution of carbon dioxide, forming a precipitate of aluminum hydroxide. In preparing aluminum hydroxide it is important that the alum solution be added to the sodium carbonate solution, and not the reverse method, as in the latter case the hydroxide will be contaminated with alkaline sulphates.

A point of importance in the manufacture of chemicals by precipitation is this very question of which chemical solution should be added to the other. The pharmacist, therefore, should carefully consult the best authorities before attempting such a precipitation, as it frequently happens that while the product yielded by one method is perfectly pure, that yielded by the reverse process is practically worthless.

One of the most interesting things in connection with aluminum hydroxide is its vast capacity for water, a fresh, well-drained magma of aluminum hydroxide containing no less than 95 per cent. of water.

Aluminum hydroxide is a valuable absorbent, and therefore useful in dusting-powders.

Aluminum acetate, $Al(C_2H_3O_2)_3$ is an easily decomposable salt that can be prepared by treating aluminum hydroxide with acetic acid. *Solution of aluminum subacetate* (N.F.) is prepared by dissolving aluminum sulphate in water, adding precipitated chalk and acetic acid and finally separating the clear fluid from the magma. It contains 7.5 to 8 per cent. of basic aluminum acetate (p. 189).

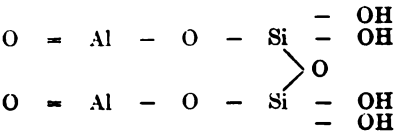
Liquor Alumini Acetatis (N.F.), or *Burow's solution*, is made by mixing solutions of lead acetate and of aluminum sulphate and finally separating the clear fluid from the magma of lead sulphate. (See p. 189.)

Liquor Alumini Acetico-tartratis (N.F.) is a similar product made from alum, sodium carbonate, acetic and tartaric acids and water. (See p. 189.)

Alumini Sulphas (U.S.P. VIII; N.F. IV) or aluminum sulphate, $Al_2(SO_4)_3 + 16H_2O$, is prepared by dissolving moist aluminum hydroxide in diluted sulphuric acid, and then granulating the salt by evaporation of the solution.

Aluminum sulphate is used internally as an antiseptic, but chiefly externally as an astringent. Its astringent properties make it of great value as a fixer in dyeing.

Kaolinum (U.S.P. VIII; N.F. IV), or *kaolin* is an aluminum silicate the formula of which is



$$\begin{array}{ccccccccc} &&&&&&&-&OH\\ O&=&Al&-&O&-&Si&-&OH\\ &&&&&&&\rangle O&\\ O&=&Al&-&O&-&Si&-&OH\\ &&&&&&&-&OH \end{array}$$

It is found largely in the Department of Allier, France, and is of great value in technic as a basis of porcelain. A description of the manufacture of porcelain is beyond the limits of this work, and for this the reader is referred to any of the leading works on chemical technology mentioned in the Preface. Kaolin is of pharmaceutic importance as having been suggested for use in the manufacture of the pills of potassium permanganate and other explosive substances, these substances being mixed with kaolin and made into a mass by the addition of soft petrolatum. Kaolin is now largely used in the form of poultice, made by triturating the finely powdered clay with glycerin to a thick paste. A similar product is *cataplasm of kaolin*, N.F. (See p. 339.)

Ultramarine, is a blue pigment made originally by pulverizing the mineral lapis lasuli. Analysis showing that this consists of silicates of aluminum and sodium combined with sulphur, its artificial production has been followed with much success. It is used to whiten sugar.

CERIUM

Symbol, Ce. Atomic weight, 139.2

Cerium is a rare metal, similar in many respects to aluminum. It is of technical importance because the "mantle" of the Welsbach burner—that well-known mode of illumination—is made of a network of oxides of cerium, thorium, didymium, and lanthanum, the last two elements usually accompanying cerium in its ores.

The sole pharmaceutic interest in cerium is because one of its salts, the oxalate, is official.

CERII OXALAS—Cerium Oxalate

(Cerii. Oxal.)

A mixture of the oxalates of cerium, didymium, lanthanum, and other associated elements.

Summarized Description.

White or slightly pink powder; insoluble in water, alcohol, ether and solutions of fixed alkalies; soluble in hot (not cold) diluted sulphuric or hydrochloric acid; yields 47 per cent. of residue at red heat. For details see U.S.P., p. 106.

For *tests for identity*, for *impurities* (carbonate, heavy metals, arsenic, aluminum and zinc) see U.S.P., p. 107.

Remarks.—Cerium oxalate of commerce, as stated in the official definition consists of true cerium oxalate CeC_2O_4 with didymium and lanthanum oxalates; a complete separation of these rare metals being practically impossible. It is made as a by-product of thorium salts from the ore, *monazite*. The thorium salts are in great demand for making Welsbach mantles.

It is a valuable remedy in the vomiting of pregnancy.

Dose.—200 milligrammes (3 grains).

CHROMIUM

Symbol, Cr. Atomic weight, approximately 52

Chromium, like manganese, aluminum, zinc, and iron, stands midway between the positive and negative elements, forming chromium salts, such as chromous sulphate, $CrSO_4$, with strong acids; and chromates, such as potassium chromate, K_2CrO_4, with alkalis.

However, it is usually more negative than positive, and in its two official compounds, chromium trioxide and potassium dichromate, it is strongly negative.

The chief ore of chromium is chrome iron ore, $FeOCr_2O_3$. (See p. 419.)

The word chromium is derived from the Greek word *chromos*, meaning color, and is so called by reason of the brilliant characteristic color of the various chromium compounds. This name was bestowed on the element by its discoverer, Vauquelin.

The element chromium is isolated either by the reduction of chromic oxide, with soot or coke, or, better, by fusion of a mixture of the chlorides of chromium, potassium, and sodium with zinc. The alkaline chlorides act as a flux, while an alloy of zinc and chromium deposits in the bottom of the crucible. This alloy is treated with diluted nitric acid, which dissolves the zinc, leaving chromium as a gray powder.

Chromium is a gray-white, brittle metal, hard enough to scratch glass, and more difficult to melt than platinum. It is not easily oxidized by contact with air.

The characteristic tests of chromium are as follows:

Ammonium sulphide precipitates, from the solution of chromium compounds, green chromic hydroxide, potassium hydroxide producing the same precipitate; lead acetate solution precipitates solutions of chromium compounds in the form of a yellow lead chromate (chrome yellow), which is rather largely esteemed as a paint. It should not, however, be used in coloring buns in place of the yolk of egg, as was tried by the bakers of Philadelphia some thirty years ago, with disastrous results.

Chromium yields several oxides—chromium oxide, CrO; chromium tetroxide, Cr_3O_4; chromic oxide, Cr_2O_3; chromium dioxide, CrO_2; chromium trioxide, CrO_3. The variation in valence represented by these oxides leads to considerable confusion, and for this reason the element chromium was omitted from the table of elements on p. 352. A similar confusion is encountered in the naming of its oxides, it being particularly unfortunate that the term chromic oxide is applied to Cr_2O_3. We have been taught that an "ic" oxide should yield the corresponding "ic" acid, and yet the official formerly called "chromic acid" is not derived from Cr_2O_3, but is none other than chromic trioxide, mentioned above.

CHROMII TRIOXIDUM—Chromium Trioxide

(Chrom. Triox.—Chromic Acid—Chromic Anhydride)

It contains not less than 95 per cent. of CrO_3 (100.00). Preserve it in glass-stoppered bottles. Caution: Chromium Trioxide should not be brought into contact with organic substances, as serious accidents are liable to result.

Summarized Description.

Small, purplish-red, needle-shape crystals or rhombic prisms; destructive to animal or vegetable tissues; deliquescent; soluble in about 0.6 part of water; decomposes (sometimes with explosions) in alcohol and other organic solvents; on heating, darkens, then fuses, then dissociates with oxygen and other chromium oxides. For details see U.S.P., p. 110.

For *tests for identity*, for *impurities* (sulphuric acid) and for *assay* see U.S.P., p. 110 and also Part V of this book.

Remarks.—This compound has the formula CrO_3. In this, as in sulphuric oxide, SO_3, the valence of the characteristic element is VI. It will be seen that this so-called acid is in reality an oxide, the true acid (the formula of which is H_2CrO_4, and thus similar to that of sulphuric acid, H_2SO_4) existing only in solution.

The official is, therefore, the anhydride of true chromic acid; an anhydride of an acid being an acid deprived of what water it possessed in the form of hydroxyl groups. This is the first acid anhydride which we have studied that is commonly given the name of the acid; the other official one being arsenous acid. In both cases they are called acids instead of oxides because they are the nearest approach to the true acid which can be obtained in the solid form, and, moreover, on dissolving these oxides in water, the true acid is produced.

Chromic acid is made by treating the potassium dichromate with a molecular quantity of sulphuric acid by the following reaction:

$$K_2Cr_2O_7 + 2H_2SO_4 = 2CrO_3 + 2KHSO_4 + H_2O.$$

It will be seen, from the equation, that only enough sulphuric acid is used to convert the potassium into potassium bisulphate. This salt is removed by crystallization, and the mother liquid then further concentrated, when the crop of chromic acid crystals is produced. These crystals cannot be dried as in ordinary cases by placing on bibulous paper, since chromium trioxide is a very powerful oxidizing agent, and will decompose most organic substances, including paper. Therefore, instead of paper, some inorganic absorbing surface must be used. For this purpose unburnt porcelain or clean fire-brick is excellent. If the use of either of these is inconvenient, drying plates of plaster of Paris can be used with excellent results. Such plates are made by making a fairly thick paste of plaster of Paris in water, and allowing same to set in an appropriate mold, for example, the cover of a pasteboard box—and after thoroughly drying the porous plate is obtained.

By reason of the oxidizing action of the chromic acid the pharmacopœia sounds a note of warning against triturating this chemical with easily oxidizable material. Hence beware of prescriptions directing chromic acid dispensed in pills. These must not be made with ordinary excipient, but with petroleum mass (kaolin and soft petrolatum). The oxidizing action of chromic acid is used for the cleaning of mortars, as already explained on p. 115. Chromic acid is also very largely used in oxidation processes in organic chemistry, for such purposes where nitric acid would act too powerfully. Medicinally, chromic acid is used almost entirely as a caustic, and its use in this way is usually limited to the removal of corns or warts. For this purpose it is very effective, but it should be applied only by a skilled operator, as careless handling of the chemical in such cases is apt to result in dangerous wounds.

Chromium sulphate, $Cr_2(SO_4)_3$, is made by treating chromic hydroxide with sulphuric acid. It occurs in dark-green scales, soluble in water and is used in neurasthenia and in prostatic troubles in 4-grain doses.

POTASSII DICHROMAS—Potassium Dichromate

This salt has already been discussed under the potassium compounds, and here it is only necessary to state that it is used chiefly as an oxidizing agent, and for this purpose is used with sulphuric acid, thus liberating chromic acid.

URANIUM

Symbol U. Atomic weight, 238.5

Uranium is one of the rarer metals whose chief ore, *pitch blend*, has recently come into prominence as the source of radium. Like radium salts, those of uranium exhibit radio-activity. One uranium salt is recognized in the present pharmacopœia.

URANII NITRAS—Uranium Nitrate

(Uran. Nit.)

It contains not less than 98 per cent. of $UO_2(NO_3)_2 + 6H_2O$ (502.62) (uranyl nitrate). Preserve it in well-closed containers, protected from light.

Summarized Description.

Light yellow, efflorescent prisms; bitter astringent taste; radio-active; freely soluble in water, alcohol and ether. For details see U.S.P., p. 483.

For *tests for identity*, for *impurities* (heavy metals, alkaline earths, iron, manganese, zinc, uranous compounds, sulphates) and for *assay* see U.S.P., p. 483 and also Part V of this book.

Remarks.—Uranyl nitrate is a salt in which uranium exhibits the valence VI. It is made dissolving uranium oxide, UrO_3, in diluted nitric acid and crystallizing the resulting fluid.

It occurs in light yellow prisms, is radio-active and is quite soluble in water, alcohol and ether. It is used (with caution) in diabetes.

Dose.—10 milligrammes (1/6 grain).

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CHAPTER XXXI

IRON

Symbol, Fe. Atomic weight, approximately 56

THE most useful and abundant of metals is *iron*. Its use is so diversified, both technically and pharmaceutically, that we must give it careful consideration. No other metal furnishes more officials, and almost without exception these are valuable.

The element is widely distributed on the earth, but in no place as the pure metal. It oxidizes (rusts) so rapidly that it cannot long remain pure in the earth's atmosphere. We find pure native iron only in meteoric stones which fall from the heavens, and are supposedly fragments of the sun's substance. This leads us to the conclusion that the sun's atmosphere must be composed of some gases other than oxygen.

The principal ores of iron found on the earth's surface are as follows: *Magnetic iron ore* or *lode-stone*. This ore, the history of which has been discussed on p. 485, has the formula Fe_3O_4, and is supposed to be a ferrous ferrate, $Fe(FeO_2)_2$, being derived from a hypothetic acid, $HFeO_2$, which is analogous to the aluminic acid already described on p. 433.

The name ferric acid is not applied to this compound, however, as it appears that there is an acid, H_2FeO_4, in which iron shows the valence VI.

The potassium salt of this acid, K_2FeO_4, is known.

This magnetic iron ore is used more by reason of its magnetic properties than as a source of iron. The commercial ores are chiefly *red hematite*, Fe_2O_3, *spathic iron ore*, $FeCO_3$ and *iron pyrites*, FeS_2. This last has already been discussed on p. 400, as one of the sources of sulphuric acid, so here it need only be stated that the term pyrites is derived from the Greek word *pyros*, fire, and is used in this case because, when the ore is struck, it emits sparks. Iron pyrites is also interesting as being the only iron compound in which iron shows the valence IV. Besides these commercial sources of iron, references should be made to the fact that this element is found in chlorophyll and in the blood, and in both cases its presence is necessary to the life of both plant and animal. So soon as the chlorophyll of the plant or the hematin of the blood becomes deficient in iron, the assimilation processes of the plant or animal economy lessens, with corresponding disastrous results to the organism. When iron is absent from the chlorophyll of plants or from the blood corpuscles, such plants or animals are said to be anemic.

Iron has been known from ancient times as one of the most valuable of metals. In fact, one of the most important steps in the development and progress of humanity is known by the anthropologists as the transition from the stone to the iron age.

VARIETIES OF IRON

The commercial forms of the metal iron can be roughly divided into three groups—cast iron, steel, and wrought iron. The difference between these three groups is based on the amount of carbon contained in the metal. Thus, *cast iron* contains from 3 to 6 per cent. carbon; *steel*, from 0.8 to 1.8 per cent. of carbon; and *wrought iron*, from 0.2 to 0.6 per cent. carbon.

The origin of these different varieties of iron is merely a question of the manipulation. Cast iron is prepared by treating the ore (an oxide of iron) with coal and limestone in the presence of a blast of air. The coal in this case acts as a reducing agent, as shown in the following equation:

$$Fe_2O_3 + C_3 = Fe_2 + 3CO.$$

The carbon monoxide produced also acts as a reducing agent on the ore, ultimately escaping as carbon dioxide (CO_2). The function of the limestone is to form a combination with the silicates naturally found in ore, the resulting calcium silicate separating in the form of *slag*, it floating on the surface of the molten iron. This process goes on in a special apparatus (blast furnace) lined with brick or fire-clay, and it is so arranged that the process is continuous; alternative layers of the ore, coal, and limestone being dumped in at the top, meeting the fiery blast produced by combustion of the preceding portions of coal about midway down in the apparatus, and molten iron drawn from the bottom.

Wrought iron is prepared by removing all the carbon from the cast iron by keeping the latter in the molten state for a time sufficient to burn the carbon contained therein by contact with the air. There are two general methods of accomplishing this result: first and oldest is called puddling, and consists of melting the cast iron in flat vessels having considerable surface exposed to the air, and stirring same vigorously with an appropriate paddle or spoon until all the carbon has combined with the oxygen of the air. In the more modern method the molten cast iron is submitted to the action of an air-blast, being constantly stirred all the while.

Steel, as will be noted above, contains a carbon percentage midway between that of cast iron and wrought iron. Hence, by the proper blending of these two forms of iron, a steel of any carbon percentage can be obtained, the calculation in this case being by the process of alligation, similar to that already described on p. 59.

This blending is performed by the Bessemer process, the operation being carried on in a special apparatus called the Bessemer converter, consisting of a huge, pear-shaped vessel, lined with fire-brick, revolving on a pivot in such a way that it can be inverted. Into this converter the molten cast iron is poured, a blast of air passed therein until the cast iron is converted into wrought iron. The wrought iron is then blended with sufficient cast iron to make a finished product of exactly the carbon content desired. Besides the Bessemer method, steel is now made largely by the open-hearth process. Crucible steel is the name given special types of steel made in high black-lead crucibles and now the Heroult furnace is used for preparing such steels. It is needless to say that this explanation of the manufacture of the three forms of iron is superficial, extended comment thereon being beyond the limits of this volume, and for full details of the process the reader is referred to the articles and books mentioned in the bibliography at the end of this chapter.

It might, however, be stated that, for the modern manufacture of steel, many recipes are employed, and each modification is usually the secret of the individual ironmaster. Thus, in making these special steels many of the rarer elements, such as uranium and vanadium are added to impart the desired toughness to the steel.

One modification of steel manufacture is worthy of passing notice. A great drawback in the manufacture of steel from the iron ore obtained in continental Europe was due to the fact that this ore contained a considerable amount of phosphorus, which caused the finished steel to be brittle, and hence comparatively useless. A remedy for this condition was discovered by Thomas and Gilchrist, who employed the simple method of lining the Bessemer converter with calcined dolomite. When the phosphorus-bearing ores were converted into wrought iron in such converters, the phosphorus was absorbed by the calcium and magnesium of the dolomite lining, with the formation of the phosphates of these two metals. Not only does this process afford a ready means of removing the phosphorus from the ore, but the dolomite lining is thereby converted into calcium and magnesium phosphates, having ready sale as a fertilizer.

The properties of iron must be discussed under the three diversified forms just described. All three forms of iron—cast iron, steel, and wrought iron—act chemically as iron, all dissolving in acids to form ferrous, and eventually ferric, salts. Another point showing their iron origin is the fact that all, when exposed to the moist atmosphere, oxidize with the formation of Fe_2O_3, which is familiar to all under the name of *iron-rust*. Physically, the three forms show a marked dis-similarity. *Cast iron*, for example, melts at 1150°C., is quite brittle, and hence breaks when hammered. This variety is called cast iron because it shares with water and with bismuth the property of expanding at the moment of solidification. *Steel* melts at 1400°C., and is the reverse of brittle, being, when properly tempered, the most elastic of metals. It is very hard, and hence it is but slightly affected by the blows of a hammer, not breaking as cast iron does, and not flattening, as does wrought iron. *Wrought iron* melts at 1500°C., and is neither brittle nor elastic, but is very malleable. In fact, a commercial term for this form of iron is *malleable iron*, and to this property is due its use in the arts.

There are now so many commercial varieties of metallic iron that the line of demarkation between cast iron, steel and wrought iron, is difficult to draw. Richards suggests that all malleable irons and steels containing less than 2 per cent. of iron be called steel and that all non-malleable iron be designated as cast iron.

Of the commercial forms of iron just mentioned, wrought iron is the nearest approach to the pure element; steel and cast iron, being now considered as mixtures of iron with varying proportions of iron carbide.

Tests.—The tests for iron and its salts are as follows: The black precipitate obtained by treating its solution with ammonium sulphide; the reddish-brown magma by treatment of ferric solutions with ammonium hydroxide, this precipitate being formerly official under the name of *ferri oxidum hydratum;* and the black coloration produced on treating an iron solution with tannin. This latter mixture, when combined with appropriate adhesive agents, forms the typical *black ink*, and is of pharmaceutic interest because such black coloration is produced whenever an iron salt is combined with the preparation of a drug containing tannin.

Besides these tests, far more characteristic are potassium fer*ri*cyanide, which gives a blue precipitate with fer*rous* salts, and potassium ferr*o*cyanide, which gives a blue precipitate with fer*ric* salts. An exceedingly delicate test for ferric salts is the red color produced by potassium sulphocyanate.

Metallic iron is recognized by the pharmacopœia in two forms, namely, *ferrum* and *ferrum reductum*.

FERRUM—Iron

(Ferr.)

Metallic iron [Fe = 55.84] in the form of fine, bright wire.

Remarks.—This is wrought iron, usually in the form of fine, bright, non-elastic wire, and a popular variety of this is what is commercially termed *card-teeth*, consisting of small points of iron wire used as the teeth of appliances employed in carding wool and cotton.

In dissolving card-teeth in acids, hydrogen is evolved, as shown in the following equation:

$$Fe +_4 H_2SO = FeSO_4 + H_2,$$

but at the same time it will be noticed that a peculiar odor is emitted. This odor is due to the hydrocarbon produced by the combination of the hydrogen with the carbon contained in the card-teeth.

Iron wire is recognized by the pharmacopœia only as a source of iron compounds, it being the most convenient form from which to make the salts of the metal.

FERRUM REDUCTUM—Reduced Iron

(**Ferr. Reduct.**—Ferrum Redactum—Iron by Hydrogen—Quevenne's Iron)

Iron reduced to the metallic state by the action of hydrogen upon ferric oxide. It contains not less than 90 per cent. of metallic iron [Fe = 55.84]. Preserve it in well-stoppered containers.

Summarized Description.

Very fine, grayish-black, lusterless powder; insoluble in water or alcohol; ignites on heating, forming ferroso-ferric oxide. For details see U.S.P., p. 172.

For *tests for identity*, for *impurities* (arsenic, sulphide) and for *assay* see U.S.P., p. 172 and also Part V of this book.

Reduced iron represents a chemically pure form of iron; hence supposedly entirely free from carbon. It is prepared by placing subcarbonate of iron (virtually, ferric oxide, Fe_2O_3) in a tube of Bohemian glass or a piece of iron piping, some four feet long, and one-half to one inch in diameter. Hydrogen, produced in the ordinary way (zinc and acid, see p. 479), is passed through the tube, which is placed in an appropriate coal or gas furnace and heat is applied after the air has been expelled from the tube by the current of hydrogen, which, passing over the heated ferric oxide, reduces it to pure iron by the following reaction:

$$Fe_2O_3 + 3H_2 = Fe_2 + 3H_2O.$$

This explains its synonym, *iron by hydrogen*.

Before removing the reduced iron from the tube, care must be taken to see that the same be perfectly cooled. If the iron be poured out while still hot, its affinity for the oxygen of the air is so great that it directly combines therewith, with the formation of a vivid flame. Such substances which spontaneously ignite when brought into contact with the air are said to be *pyrophoric*, and as a striking illustration may be cited antimony sulphide. Some writers claim that pure reduced iron is not pyrophoric, that phenomena being caused by presence of ferrous oxide, FeO.

Reduced iron is a valuable tonic.

Dose.—60 milligrammes (1 grain).

The following compounds of iron are official:

Ferrous Salts:

- Saccharated ferrous carbonate. At least 15 per cent. absolute $FeCO_3$.
- Mass of ferrous carbonate. At least 35 per cent. absolute $FeCO_3$.
- Pills of ferrous carbonate. At least 0.06 Gm. $FeCO_3$ to each pill.
- Syrup of ferrous iodide, 4.75 to 5.25 per cent. absolute FeI_2.
- Pills of ferrous iodide contain 0.04 Gm. iron and 0.05 Gm. iodine to each pill.
- Ferrous sulphate. At least 99.5 per cent. absolute $FeSO_4 + 7H_2O$.
- Exsiccated ferrous sulphate. At least 80 per cent. absolute $FeSO_4$.
- Granulated ferrous sulphate, $FeSO_4 + 7H_2O$.

Ferric Salts:

- Ferric chloride ($FeCl_3$) contains at least 20 per cent. metallic iron.
- Solution of ferric chloride contains 29 per cent. absolute $FeCl_3$ or 10 to 11 per cent. metallic iron.
- Tincture of ferric chloride contains about 13 per cent. absolute $FeCl_3$ or 4.48 per cent. metallic iron.
- Ferric hydroxide with magnesium oxide. A magma consisting of $Fe(OH)_3$, magnesium sulphate, and water.

Solution of ferric sulphate contains about 36 per cent. $Fe_2(SO_4)_3$ or 9.5 to 10.5 per cent. metallic iron.
Solution of ferric subsulphate consists of basic ferric sulphate; contains 13 to 14 per cent. metallic iron.
Solution of iron and ammonium acetate. A pharmaceutical containing 4 per cent. tincture of ferric chloride.

Scale Salts of Iron:
Iron and ammonium citrate contain at least 16 per cent. metallic iron.
Iron and quinine citrate contain at least 13 per cent. metallic iron.
Ferric phosphate contains at least 12 per cent. metallic iron.

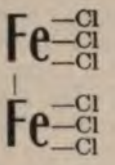
It will be seen that iron compounds in the above table are grouped into ferrous salts, ferric salts, and scale salts of iron. The latter, which are pharmaceutic preparations rather than definite chemicals, will be discussed by themselves (p. 517). The ferrous salts and ferric salts are combinations of acids with iron, the latter exhibiting two different valences.

Reference to the elemental table on p. 352 shows that iron is one of the positive elements which possess more than one valence, and that, while the variation in the valence of negative elements is almost invariably a difference of two—say I, III, V, VII, or II, IV, VI—thus agreeing with Frankland's bond idea, explained on p. 350, the variation of iron, expressed in that table, is II and III, the two phases of the element being expressed as ferrous and ferric respectively.

The formulas of ferrous compounds, such as ferrous iodide, FeI_2, or ferrous sulphate, $FeSO_4$, are easy to comprehend if one bears in mind that bivalent iron—iron with two free bonds—acts exactly as does bivalent calcium, and all that was said of the formulas of alkaline earth metals on p. 459 applies to ferrous salts.

In giving the valence III to the ferric form clearness is possibly sacrificed for brevity, and it is well to explain that there has been much discussion on the valence of ferric iron, some giving the valence III (Fe^{III}), and others giving two molecules of iron with the valence VI—$(Fe_2)^{VI}$. The latter view was that accepted by the United States Pharmacopœia of 1890, but at the revision of 1900 the trivalent view was accepted, and as a result the formula of ferric chloride is given as $FeCl_3$ in the present pharmacopœia.

The formula Fe_2Cl_6 is accepted by some chemists (Deville and Troust. also Friedel and Crafts) because, in the first place, the molecular weight estimations place it nearer that of the formula Fe_2Cl_6 than that of $FeCl_3$, and then, too, if the formula Fe_2Cl_6 prevails, it would show the valence of ferric iron to be IV, thus maintaining the regularity in valence variation noticeable in the negative elements. If iron has the valence IV, two atoms would link together just as two carbon atoms link in ethane (see p. 567), giving the following formula:



$$\begin{array}{l} Fe\begin{smallmatrix}-Cl\\-Cl\\-Cl\end{smallmatrix} \\ \,| \\ Fe\begin{smallmatrix}-Cl\\-Cl\\-Cl\end{smallmatrix} \end{array}$$

Fe_2Cl_6

The only reason that such formulas as $FeCl_3$ are employed instead of Fe_2Cl_6 is for sake of brevity.

FERROUS SALTS

Ferrous carbonate, $FeCO_3$, is official in three forms: the saccharated, the mass and the pills. In all these preparations the carbonate is manufactured in about the same way—treatment of ferrous sulphate with an alkaline carbonate. In the saccharated, sodium bicarbonate is used; and in the other two, potassium carbonate is employed, the reaction in the latter case being—if we use crystallized ferrous sulphate—

$$\underset{278}{FeSO_4 7H_2O} + \underset{138}{K_2CO_3} = \underset{174}{K_2SO_4} + \underset{116}{FeCO_3} + \underset{126}{7H_2O}.$$

This means that every 278 grammes of crystallized ferrous sulphate will produce 116 grammes of ferrous carbonate. If sodium carbonate is used the reaction will be similar except that sodium sulphate will be the by-product.

Uncombined ferrous carbonate is very unstable, going over into ferric oxide by the following reaction:

$$2FeCO_3 + \underset{\text{(From the air)}}{O} = 2CO_2 + Fe_2O_3.$$

The iron carbonate or subcarbonate of iron usually found in stores, a red-brown powder, is almost entirely Fe_2O_3—common iron-rust. The oxidation of the carbonate may be partly prevented by protecting the salt with sugar, and accordingly we find that all four official preparations just mentioned have sugar as an ingredient.

FERRI CARBONAS SACCHARATUS—Saccharated Ferrous Carbonate

(Ferr. Carb. Sacch.)

Saccharated Ferrous Carbonate contains not less than 15 per cent. of $FeCO_3$ (115.84). Preserve it in small, well-stoppered bottles, exposed to light.

Condensed Recipe.

Dissolve 50 Gm. ferrous sulphate in 200 mils of hot distilled water, add a few drops of diluted sulphuric acid and filter; dissolve 35 Gm. sodium bicarbonate in 500 mils of distilled water at 50°C. and filter. Put the soda solution into a flask, pour in the iron solution, fill flask with boiling distilled water and let mixture stand until sedimented. Then siphon off supernatant liquid, wash precipitate by sedimentation and siphoning until free from sulphates, strain on strainer, mix with sugar and sugar of milk, evaporate on a water-bath to dryness and then powder, adding enough sugar to make 100 Gm. For details see U.S.P.

Summarized Description.

Greenish-brown powder; gradually oxidized in air; sweetish ferruginous taste; partly soluble in water; completely soluble in diluted hydrochloric acid, with effervescence. For details see U.S.P., p. 165.

For *tests for identity*, for *impurities* (sulphates) and for *assay* see U.S.P., p. 165 and also Part V of this book.

It will be seen, from the above process, that this compound is made by pouring a solution of ferrous sulphate into a solution of sodium bicarbonate, and washing the precipitated ferrous carbonate with boiling water, all the time using precautions to prevent access of air. The washed precipitate is then mixed with sugar, and evaporated to dryness on a water-bath, and finally mixed with a sufficient quantity of sugar to make the finished product contain about 15 per cent. of ferrous carbonate.

The saccharated carbonate has all the properties of ferrous carbonate, and is a chalybeate tonic, particularly indicated in anemia.

Dose.—250 milligrammes (4 grains).

MASSA FERRI CARBONATIS—Mass of Ferrous Carbonate

The recipe for this body, commonly called *Vallet's mass*, as well as full details of manufacture, will be found in Part VII.

It is made by pouring a solution of ferrous sulphate into a solution of sodium carbonate, removing the resulting sodium sulphate by washing with warm water, to which a sufficient amount of syrup has been added to prevent oxidation; the drained product is then combined with honey and syrup. This preparation should contain at least 35 per cent. of ferrous carbonate, as is figured out on p. 1001.

Dose.—250 milligrammes (4 grains).

PILULÆ FERRI CARBONATIS—Pills of Ferrous Carbonate

(**Pil. Ferr. Carb.**—Chalybeate Pills—Blaud's Pills—Ferruginous Pills)

Each pill contains not less than 0.06 Gm. of $FeCO_3$.

Condensed Recipe.

Rub 8 Gm. potassium carbonate in a mortar with about 5 drops of glycerin and 5 drops of water, add 16 Gm. granulated ferrous sulphate and 4 Gm. sugar and triturate until a green paste results. Then add 1 Gm. tragacanth and 1 Gm. althæa and work into a mass, using more water if necessary. Divide the mass into 100 pills. For details see U.S.P., p. 324.

Assay.—See Part V.

It will be seen that these pills, which are commonly called *Blaud's pills*, are made by treating potassium carbonate with ferrous sulphate and sugar, glycerin, and water, and finally incorporating althæa and tragacanth as excipients. The mass is cut and rolled into pills. In making these pills it would be well if no reaction took place between the potassium carbonate and ferrous sulphate until the pill had dissolved in the juices of the stomach.

By directing that the mass be beaten thoroughly until it assumes a greenish color, the pharmacopœia defeats this purpose and affords a product distinctly inferior to Vallet's mass. From the latter the alkaline sulphate has been removed, and the ferrous carbonate is protected by the use of sugar and honey; whereas, the pills, of which we are speaking, still contain the potassium sulphate and a lesser amount of protecting sugar. Leubner claims, however, that the pills, when properly made, keep in good condition as long as 15 years. Efforts to make Blaud's pills in which the reaction has not taken place has resulted in many ingenious devices: for instance—one firm furnishes a gelatin-coated pill in which the ferrous sulphate is placed in one-half and the potassium carbonate in the other half, being separated in the gelatin membrane. The retail pharmacist can easily prepare a similar form of pill, if he so desires, by placing the constituents, one on top of the other, in a gelatin capsule, the two chemicals being separated by a layer of sugar of milk.

Dose.—2 pills.

Mistura Ferri Composita (U.S.P. VIII; N.F. IV) or *Griffith's mixture* is made by placing a mixture of myrrh, sugar, potassium carbonate, and rose water into a dispensing bottle, adding thereto spirit of lavender, and lastly a solution of ferrous sulphate in rose water.

This preparation should be freshly prepared in the bottle in which it is to be sent out. When the ferrous sulphate is added to the potassium carbonate, an evolution of carbon dioxide usually occurs, and care must be taken to permit the complete escape of this gas before the bottle be corked, otherwise there is danger of the fracture of the flask. The preparation, when fresh, is a bluish-green mixture, but on standing, especially when a few doses have been taken from the bottle, it changes to a brick-dust red—into the so-called subcarbonate of iron. The instability of this preparation makes its use, at its best, somewhat questionable, and in dispensing it the pharmacist should mention to the purchaser the color change which is bound to occur.

It is used as a ferruginous tonic in tablespoonful doses.

"Fluid" Ferrous Carbonate.—Wilbert has suggested dissolving 3.2 grammes of granulated ferrous sulphate in 1.5 mils of water and adding 50 mils of glycerin; 1.6 grammes of potassium carbonate are then dissolved in 50 mils glycerin; the two fluids are mixed without any precipitation. But on adding any of the mixed fluid to water, the reaction between the sulphate and the carbonate begins with the precipitation of ferrous carbonate. Each 5 mils of the fluid represents the amount of ferrous carbonate in one Blaud's pill.

Ferrous chloride, $FeCl_2$, is the leading constituent of *liquor ferri protochloridi* N.F. This is made by preparing a solution of ferrous chloride from card-teeth and a diluted hydrochloric acid and mixing this solution with glycerin and diluted hypophosphorous acid.

Ferrous iodide, FeI_2, is another of the unstable salts of iron, to preserve which it is necessary to add sugar or some other substance capable of preventing oxidation by the atmosphere.

The reaction of manufacture is very simple: $Fe + I_2 = FeI_2$.

The salt is official in three different forms: The *saccharated*, the *syrup*, and the *pills*, which are coated with the balsam of tolu to prevent atmospheric action.

As is the case with ferrous carbonate, ferrous iodide is very unstable, splitting, when coming in contact with air, into ferric hydroxide, iodine, and hydriodic acid, as shown in the following equation:

$$FeI_2 + 2H_2O + \underset{\text{(From the air)}}{O} = Fe(OH)_3 + I + HI.$$

This decomposition is largely obviated by combining ferrous iodide with sugar or hypophosphorus acid.

Ferri Iodidum Saccharatum (U.S.P. 1890) was made by preparing a solution of ferrous iodide by treatment of iodine with iron wire, mixing the filtered solution with sugar of milk, evaporating to a dry mass, and then mixing with sufficient sugar of milk to make a product containing 20 per cent. of ferrous iodide.

This product was very unstable, and hence was wisely omitted at the last revision.

SYRUPUS FERRI IODIDI—Syrup of Ferrous Iodide

(**Syr. Ferr. Iod.**—Ferri iodidi syrupus P. I.)

A syrupy liquid containing not less than 4.75 per cent. nor more than 5.25 per cent. of FeI_2 (309.68). Preserve it in completely filled, tightly stoppered bottles.

Manufacture.—See Part VII.

Summarized Description.

Transparent, pale-yellow, syrupy liquid; sweet, ferruginous taste; slightly acid reaction; sp. gr., 1.35. For details see U.S.P., p. 429.

For *tests for identity*, for *impurities* (iodine) and for *assay* see U.S.P., p. 429 and also Part V of this book.

Remarks.—This syrup is made by treating iron with iodine, filtering the solution of ferrous iodide (to which a small amount of sugar has been added) into the rest of the sugar, which is dissolved therein with heat. The finished syrup is preserved by addition of a small amount of hypophosphorous acid. The syrup of the present pharmacopœia contains about 5 per cent. ferrous iodide, while that of the U.S.P. 1890 was 10 per cent.

The color of spoiled ferrous iodide can be changed from the brown to the bright green by the addition of a small quantity of card-teeth or reduced iron, this seeming to show that the brown coloration is due to the presence of free iodine, rather than caramel, as has been suggested by one writer. While the problem is still undecided, it behooves the careful pharmacist never to dispense a syrup that has turned brown.

The syrup of ferrous iodide is given as an alterative and chalybeate tonic, diluted with water, and always taken through a tube, as the ferrous iodide attacks the teeth.

Dose.—1 mil (15 minims).

PILULÆ FERRI IODIDI—Pills of Ferrous Iodide

(Pil. Ferr. Iod.)

Condensed Recipe.

Mix 4 Gm. reduced iron with 6 mils of water, add 5 Gm. iodine and triturate until free from red tint. Then add 4 Gm. powdered glycyrrhiza, 4 Gm. sugar, 1 Gm. extract of glycyrrhiza, and 1 Gm. powdered acacia, triturate to a paste, heat on a water-bath to pilular consistence and divide into 100 pills. Coat these with a solution of 10 Gm. balsam of tolu in 15 mils of ether. For details see U.S.P., p. 325.

Impurity.—Free iodine, see U.S.P.

Remarks.—These pills are made by triturating reduced iron, iodine and water until the red tint has disappeared; mixing with glycyrrhiza, sugar, extract of glycyrrhiza and acacia, beating the mass to a pilular consistence, and coating the pills with an ethereal solution of balsam of tolu. As already mentioned, these pills and the pills of phosphorus are the only two directed by the pharmacopœia to be coated, and in both cases the coating is not intended to enhance the beauty of the pills, but to prevent oxidation of the active ingredient.

Each pill contains about one grain of ferrous iodide.

Dose.—2 pills.

Ferri Lactas (U.S.P. 1890; N.F. IV), or ferrous lactate, $Fe(C_3H_5O_3)_2 + 3H_2O$, is the ferrous salt of lactic acid (the composition of which will be found on p. 609) and is made by treating lactic acid with reduced iron, and subsequently evaporating the solution to dryness.

This ferrous preparation is the iron constituent of the formerly official *syrup of hypophosphites with iron*, where it is directed because it is supposed to be a most easily assimilable salt of iron. This claim has never been thoroughly substantiated, and the preparation is one of doubtful value.

It is administered in 10-grain doses.

Ferrous sulphate ($FeSO_4$), called "green vitriol," from the Latin *vitreus*, glass, because the crystals look like green glass. When we distil these crystals, an oily liquid passes over, and this, the alchemists of three hundred years since, called "oil of vitriol," a name that still clings to the distillate—sulphuric acid.

In an impure form ferrous sulphate is called "copperas," although containing no copper whatever.

Ferrous sulphate is official in three forms: The crystalline, containing seven molecules of water of crystallization; the granulated, which contains the same amount of water as do the crystals (turn to Granulation on p. 151), and, lastly, the exsiccated, which represents the crystalline minus the greater quantity of its water, 100 parts of the crystals yielding 64 parts of the exsiccated. The dried is preferable to the crystalline in the manufacture of pills, being of smaller bulk and not causing a soft mass. Note in these two officials—the crystalline and the dried—an interesting demonstration of the influence of water of crystallization on a substance. Dried ferrous sulphate is a grayish-white, opaque powder; while the crystals, which differ from the dried only by the presence of water of crystallization, are green and transparent.

FERRI SULPHAS—Ferrous Sulphate

(**Ferr. Sulph.**—Iron Protosulphate.)

It contains not less than 54.36 nor more than 57.07 per cent. of anhydrous ferrous sulphate, corresponding to not less than 99.5 per cent. of the crystallized salt [$FeSO_4 + 7H_2O = 278.02$]. Preserve it in well-closed containers.

Summarized Description.

Pale, bluish-green, efflorescent, monoclinic prisms; saline styptic taste; oxidizes on exposure to air, becoming coated with brown-yellow basic ferric sulphate; soluble in about 1.4 parts of water; insoluble in alcohol. For details see U.S.P., p. 170.

For *tests for identity*, for *impurities* (free acid, heavy metals) and for *assay* see U.S.P., p. 170 and also Part V of this book.

Remarks.—This salt is made by treating scrap iron with sulphuric acid, and evaporating the solution to a point where the green crystals will be obtained. These green crystals are not very stable, comparatively readily combining with oxygen of the air, with the formation of basic ferric sulphates by the following reactions:

$$(a)\ 2FeSO_4 + O = Fe_2O(SO_4)_2.$$
$$(b)\ 2FeSO_4 = Fe_2O_2SO_4 + SO_2.$$

The present pharmacopœia directs that this brown efflorescent salt must not be used for any official purpose.

In order to insure the formation of a perfectly green ferrous sulphate, it is usually advisable to crystallize from acid solution containing some card-teeth, the latter acting on the acid with the constant evolution of hydrogen. Thus, cheap copperas can be converted into beautiful crystals of ferrous sulphate by dissolving in water, adding a small quantity of sulphuric acid and some card-teeth, and warming gently until a green solution is obtained. This is filtered from the undissolved ferric oxide and allowed to crystallize.

Ferrous sulphate is used as an astringent and chalybeate tonic.

Dose.—100 milligrammes (1½ grains).

FERRI SULPHAS GRANULATUS—Granulated Ferrous Sulphate

Official recipe, slightly modified, and details of manufacture will be found in Part VII.

Remarks.—This official represents ferrous sulphate in the form of small crystals called granules. It is prepared by dissolving ferrous sulphate in water containing diluted sulphuric acid, evaporating to a certain degree of concentration, and stirring the mixture while it is cooling. (See p. 151.) In this way the salt separates into small crystals, which are immediately transferred to a funnel, stoppered with a plug of cotton, the mother liquid allowed rapidly to drain off, and the crystals then freed from the remaining adhering water by pouring on a small quantity of alcohol; the object of washing with alcohol being to dry the granules as rapidly as possible, and that without a loss of water of crystallization. It should be emphasized that, theoretically, granulated ferrous sulphate contains exactly the same amount of water as does the crystalline, although in practice it usually loses a small amount of its water of hydration by efflorescence.

Dose.—100 milligrammes (1½ grains).

FERRI SULPHAS EXSICCATUS—Exsiccated Ferrous Sulphate

Official recipe and details of manufacture will be found in Part VII.

Remarks.—This preparation is made by efflorescing crystallized ferrous sulphate and then exsiccating on a sand-bath; 100 grammes of the crystallized yielding 64 to 65 grammes exsiccated salt.

It will be seen that the exsiccated salt is a much more concentrated preparation than the crystalline, and, therefore, for a similar dose, about three-fifths as much need be given. It is admirably adapted for pills, since the same amount of ferrous sulphate can be given in the exsiccated form in a much smaller bulk.

Dose.—60 milligrammes (1 grain).

Ferrous oxalate (U.S.P. 1890), FeC_2O_4, is made by treating ferrous sulphate with oxalic acid, and this process explains the value of oxalic acid as a remover of ink-stains. Most black ink is tannate of iron, and if to this oxalic acid be added, the tannic acid is replaced by oxalic acid, and the resulting ferrous oxalate leaves a light yellow stain, instead of the pronounced black of the ink, and while the stain is as insoluble as is ink, it does not show. In using oxalic acid for this purpose great care must be taken lest it injure the fabric.

FERRIC SALTS

Having already given the structure of ferric salts our careful consideration, we can proceed to the discussion of the compounds themselves, commencing with one that will thoroughly explain the transition from the ferrous to the ferric state, namely:

FERRI CHLORIDUM—Ferric Chloride

(**Ferr. Chlor.**—Iron Perchloride)

It contains $FeCl_3$ (162.22) in a hydrated form corresponding to not less than 20 per cent. of Fe. Preserve it in well-closed glass containers.

Summarized Description.

Orange-yellow, deliquescent, crystalline pieces; strongly styptic taste; soluble in about 0.2 part of water; also soluble alcohol, glycerin or ether; on heating, first fuses, then dissociates into water, hydrochloric acid and ferric oxide. For details see U.S.P., p. 166.

For *tests for identity*, for *impurities* (zinc, lead, copper, alkaline salts, nitric acid, ferrous salt) and for *assay* see U.S.P., p. 166 and also Part V of this book.

Remarks.—In making this salt, we first treat iron with hydrochloric acid, which gives us ferrous chloride, $FeCl_2$, by the following reaction:

$$Fe + 2HCl = H_2 + FeCl_2.$$

It is important to note that usually a metal treated with an acid will yield an "ous" salt of that metal; that salt exhibiting the metal in its lowest valence. Hence we get in this case ferrous chloride, which is analogous to ferrous oxide, which we do not want. We wish ferr*ic* chloride, and how are we to get it? How did we make sulphur*ic* oxide from sulphur*ous* oxide? See p. 399; by oxidizing with nitric acid; and that is exactly what we do with ferrous chloride to change it into ferric chloride; the reaction being:

$$6FeCl_2 + 6HCl + 2HNO_3 = N_2O_2 + 4H_2O + 3Fe_2Cl_6.$$

Compare this reaction with that of the conversion of sulphurous oxide to sulphuric oxide, given on p. 399, and the analogy will be noted.

The three molecules of HNO_3 break into N_2O_2, H_2O, and three atoms of oxygen, and on the basis of the three atoms of oxygen, yielded by the two molecules of nitric acid, hangs the entire proportion of the equation.

Note that in this oxidation the oxygen does not combine with the iron, but that it seizes the hydrogen of the hydrochloric acid, setting the chlorine free and giving it a chance to combine with the iron of the ferrous chloride. This is a confirmation of the assertion on p. 398 that the function of an oxidizing agent is not merely that of adding oxygen to a substance, but that its main effort is toward raising the valence of one of the elements entering into the reaction. Moreover, the element whose valence is raised is not necessarily the one which is oxidized.

In practice, ferric chloride is first made in the form of the official solution and this is then evaporated to about 40 per cent. of its original weight and the residue is set aside until it forms a crystalline mass.

The pharmacopœial statement that ferric chloride is soluble in a mixture of ether and alcohol is made use of in Rothe's process for the quantitative estimation of iron.

The official ferric chloride is used as a styptic externally, and internally as a tonic.

Dose.—60 milligrammes (1 grain).

LIQUOR FERRI CHLORIDI—Solution of Ferric Chloride

(**Liq. Ferr. Chlor.**—Solution of Iron Perchloride)

An aqueous solution containing ferric chloride [$FeCl_3$ = 162.22], corresponding to not less than 10 per cent. nor more than 11 per cent. of Fe. Preserve it in glass-stoppered bottles protected from light.

Condensed Recipe.

Heat 125 Gm. card-teeth (p. 501) with a mixture of 420 Gm. hydrochloric acid with 250 mils of distilled water on a water-bath until effervescence ceases (or for one and one-fourth hours). Then boil the mixture, filter, wash the filter with hot distilled water, add to the filtrate 220 Gm. hydrochloric acid, and add the mixture to 65 Gm. nitric acid contained in a large porcelain evaporating dish. Then warm gently, add more nitric acid if the liquid is black and warm until the liquid is clear reddish-brown and until effervescence ceases. Then evaporate in a sand-bath until free from nitric acid, adding water as necessary. Lastly, add 40 Gm. hydrochloric acid and enough water to make 1000 Gm. For details see U.S.P., p. 240.

Summarized Description.

Reddish-brown liquid; acid, strongly styptic taste; acid reaction; sp. gr. 1.29 to 1.32. For details see U.S.P., p. 241.

For *tests for identity*, for *impurities* (zinc, copper, lead, alkaline salts, nitric acid, ferrous salts) and for *assay* see U.S.P., p. 241, and also Part V of this book.

This preparation contains about 29 per cent. of anhydrous salt, the solution containing an excess of free hydrochloric acid. It is rarely administered in medicine, the tincture of ferric chloride being preferred for internal use, and Monsel's solution is better for external styptic purposes.

Dose.—0.1 mil (1½ minims).

Liquor Ferri Oxychloridi (N.F.) is made by preparing ferric hydroxide from solution of ferric chloride and ammonia water and then adding to the washed magma, hydrochloric acid (not quite enough to make a normal chloride) glycerin and water.

TINCTURA FERRI CHLORIDI—Tincture of Ferric Chloride

(**Tr. Ferr. Chlor.**)

A hydro-alcoholic solution containing ferric chloride [$FeCl_3$ = 162.22] (about 13 per cent.), corresponding to not less than 4.48 per cent. of Fe. Protect Tincture of Ferric Chloride from light.

Condensed Recipe.

Mix 350 mils of solution of ferric chloride with enough alcohol to make 1 liter; let stand three months before dispensing. For details see U.S.P., p. 454.

Summarized Description.

Bright, amber-colored liquid; slightly ethereal odor; astringent styptic taste; acid reaction; sp. gr. 1.00. For details see U.S.P., p. 454.

For *tests for identity*, for *impurities* (nitric acid) and for *assay* see U.S.P., p. 454 and also Part V of this book.

Remarks.—This galenic preparation is made by combining 350 mils of solution of ferric chloride with alcohol, to make 1000 mils, and allowing same to stand for three months before dispensing, in order that the free hydrochloric acid found in the solution will have time to act on the alcohol and form compound ethers, which render it more active.

It is sometimes confusing to a student to read superficially that this tincture contains 35 per cent. of the solution, which contains about 29 per cent. of ferric chloride and then note that the actual ferric chloride content of the tincture is about 13 per cent. The following figures show, however, that the latter statement is correct:

1000 mils of tincture of ferric chloride contain 350 mils of solution of ferric chloride.
1000 mils of the tincture weigh the same as water, 1000 grammes.
1000 grammes of the tincture contain 350 mils of the solution.
1000 grammes of the solution contain 290 grammes of dry ferric chloride.
1000 grammes of the solution measure 1000 ÷ 1.3 or 769 mils.
769 mils of the solution contain 290 grammes of dry ferric chloride.
350 mils of the solution contain $^{350}/_{769} \times 290$ or about 131.9 grammes of dry ferric chloride.

Hence 1000 grammes of the tincture contain 350 mils of solution or 131.9 grammes of ferric chloride; hence the tincture contains 13.19 per cent. $FeCl_3$.

The tincture of ferric chloride is one of the most satisfactory means for the administration of iron. The chief objection is the fact that, when taken directly into the mouth, it is apt to injure the teeth, due partly to the iron, but chiefly to the excess of acid present in the preparation. It is, therefore, generally directed to be administered largely diluted with water and sucked through a tube. A very simple and effective method of administration, totally devoid of any danger of injuring the teeth, is to drop the dose of the tincture into a gelatin capsule of appropriate size, say, No. 2 or No. 3, and then swallow the same immediately in a draught of water. Such capsules are unstable, the water in the tincture dissolving the gelatin, and hence must be made by the patient at the moment of administration—a very simple matter when the proper directions are given.

Dose.—0.5 mil (8 minims).

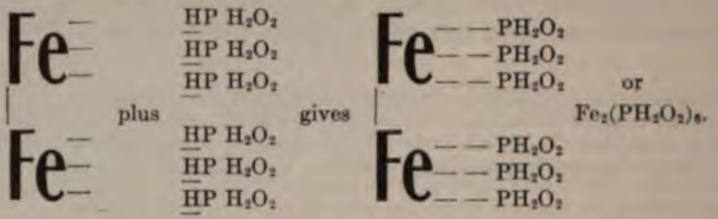
The tincture of ferric chloride is an ingredient of the *solution of iron and ammonium acetate.* (See p. 516.)

Tincture Ferri Citro-chloridi (N.F.) was devised by Cruse, under the name of *tasteless tincture of iron* and is made by treating solution of ferric chloride with sodium citrate and adding alcohol and water. It is a beautiful green fluid and is valuable inasmuch as prescriptions calling for tincture of ferric chloride along with alkaline phosphates can frequently be compounded without precipitation, if the equivalent quantity of the tincture of the citro-chloride is employed. Like tincture of ferric chloride U.S.P. the tincture of citro-chloride represents 350 mils of the official solution to the liter.

Tinctura Ferri Chloridi Aetherea (N.F.) or *Bestuscheff's tincture*, is an ethereal tincture of ferric chloride. It is made by mixing 6 parts of the official solution of ferric chloride with enough of a mixture of alcohol and ether to make one liter and letting the mixture stand in the sunlight until it is bleached.

Ferri Hypophosphis (U.S.P. VIII; N.F. IV) or *ferric hypophosphite* $Fe(PH_2O_2)_3$, seems to present a very difficult symbolic formula. However, a complete explanation of the formula of hypophosphorous acid, HPH_2O_2, is given on p. 406. The formula there given shows but one hydroxyl group, and a dictum in chemistry is that in all inorganic acids, save the haloids, only those hydrogen atoms found in a hydroxyl group are replaceable by a metal. Hence hypophosphorous acid has but one replaceable hydrogen; unlike its near relative, phosphoric acid, whose graphic formula, given on p. 359, shows it to have three hydroxyls, and therefore three replaceable hydrogens.

Since one molecule of hypophosphorous acid contains but one atom of replaceable hydrogen, and since the valence of ferric iron is III, if preferred, $(Fe_2)^{VI}$, two atoms of ferric iron, which can replace six atoms of hydrogen, will combine with six molecules of hypophosphorous acid, thus:



or $Fe_2(PH_2O_2)_6$.

This salt is made by treating a solution of calcium hypophosphite with a solution of ferric chloride, when ferric hypophosphite is produced by the following reaction:

$$3Ca(PH_2O_2)_2 + Fe_2Cl_6 = 2Fe(PH_2O_2)_3 + 3CaCl_2.$$

In this case calcium chloride dissolves, while the ferric hypophosphite precipitates.

Ferric hypophosphite possesses properties similar to all hypophosphites, with the additional advantage of being a chalybeate tonic. It is given in 3-grain doses.

Liquor Ferri Hypophosphis (N.F.) is a 16.5 per cent. solution of ferric hypophosphite in glycerin and water; potassium citrate being added to facilitate the dissolving of the iron salt.

Ferric Valerianate (U.S.P. 1890), $Fe(C_5H_9O_2)_3$, is the ferric salt of valerianic acid, the chemistry of which will be found on p. 617. It is made by the double decomposition of sodium valerianate with ferric sulphate, the reaction being as follows:

$$6NaC_5H_9O_2 + Fe_2(SO_4)_3 = 3Na_2SO_4 + 2Fe(C_5H_9O_2)_3.$$

The insoluble ferric valerianate thus produced is separated from the sodium sulphate by filtration and subsequent washing of the precipitate.

The ferric valerianate is given as a tonic and nervine in doses of from 0.3–0.6 Gm. (5–10 grains).

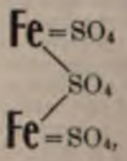
Ferri et Ammonii Sulphas (U.S.P.) or *ferric ammonium sulphate*, is the well-known *ferric alum*, the chemistry of which was thoroughly explained on p. 492 among the other alums, hence we only need to emphasize the analogy between the official alum and ferric alum:

Alum (U.S.P.) is .... $K_2SO_4Al_2(SO_4)_3 24H_2O$.
Ferric alum is .... $(NH_4)_2SO_4Fe_2(SO_4)_3 24H_2O$.

Ferric alum is made by combining molecular quantities of the solution of ferric sulphate with a solution of ammonium sulphate. On evaporating the mixture the pure crystals of ferric alum separate, leaving the dark-brown mother liquor. As already mentioned on p. 492, ferric alum possesses very few of the properties of the average iron salt, being much more similar to the alums.

It is used as styptic and very rarely internally.

Ferric sulphate, $Fe_2(SO_4)_3$, which is graphically is official in the form of a *solution* containing about 36 per cent. of ferric sulphate—called liquor ferri *ter*sulphatis, to distinguish it from the official solution of the basic salt, *liquor ferri subsulphatis*, which is commonly called "Monsel's solution."



LIQUOR FERRI TERSULPHATIS—Solution of Ferric Sulphate

(**Liq. Ferr. Tersulph.**—Solution of Iron Tersulphate)

An aqueous solution containing normal ferric sulphate [$Fe_2(SO_4)_3$ = 399.89], corresponding to not less than 9.5 per cent. nor more than 10.5 per cent. of Fe.

Manufacture.—See Part VII.

Summarized Description.

Yellowish-brown liquid; acid, strongly styptic taste; acid reaction; miscible with alcohol and with water; sp. gr. 1.432. For details see U.S.P., p. 244.

For *tests for identity*, for *impurities* (nitric acid, ferrous salt) and for *assay* see U.S.P., p. 244 and also Part V of this book.

Remarks.—Solution of ferric sulphate is made by the oxidation of ferrous sulphate with nitric acid, and by a process entirely analogous to that described under the head of ferric chloride. Details on p. 509. As in the case of ferric chloride, it is seen that, to accomplish this result, not only is nitric acid necessary, but also an additional quantity of the characteristic acid, in this case sulphuric acid, the amount of the latter being directly proportional to the difference in SO_4 groups expressed in the two formulas, ferrous sulphate and ferric sulphate.

The solution of tersulphate of iron is one of the most important of the iron preparations, although very rarely called for in prescriptions or at the counter. It is the basis of all the scale salts of iron, and is the iron constituent used in preparing the antidote for arsenic. For this reason, if for no other, the pharmacist must keep in stock a solution of tersulphate of iron.

It is worth noting that the ferric sulphate of this preparation is the true persulphate of iron, though, through an unfortunate blunder, custom has established the precedent of calling the solution of subsulphate of iron "solution of persulphate of iron."

LIQUOR FERRI SUBSULPHATIS—Solution of Ferric Subsulphate

(**Liq. Ferr. Subsulph.**—Monsel's Solution—Solution of Basic Ferric Sulphate)

An aqueous solution containing basic ferric sulphate corresponding to not less than 13 per cent. nor more than 14 per cent. of Fe.

Condensed Recipe.

Dilute 65 Gm. sulphuric acid with 500 mils of distilled water in a porcelain evaporating dish, heat to 100°C. and add 70 Gm. nitric acid. Then add 675 Gm. coarsely powdered ferrous sulphate divided into four equal portions and add these portions, one at a time, to the hot liquid, stirring after each addition until effervescence ceases. If, after adding all of the ferrous sulphate the liquid is black, add enough more nitric acid to complete the oxidization (see p. 509); then boil until the solution is free from nitric acid, adding enough distilled water to prevent too great concentration. Lastly, add enough distilled water to make 1000 Gm. For details see U.S.P., p. 243.

Summarized Description.

Dark reddish-brown liquid; acid, strongly styptic taste; miscible with water and alcohol; sp. gr. 1.548. For details see U.S.P., p. 243.

For *tests for identity*, for *impurities* (nitric acid, ferrous salt) and for *assay* see U.S.P., p. 243 and also Part V of this book.

Remarks.—This is commonly called Monsel's solution. The prefix "sub" means a basic salt—a combination of an oxide of a metal with a salt of the same metal. Thus, ferric *sub*sulphate is a combination of ferric sulphate and ferric oxide; bismuth *sub*nitrate is a combination of bismuth nitrate and bismuth oxide; and so on. Note that in the pharmacopœia definition given above, no symbolic formula is assigned the iron salt found in Monsel's solution. In the pharmacopœia of 1880 the formula was given as $Fe_4O(SO_4)_5$, which may be untangled as follows:

If we take three molecules $Fe_4O(SO_4)_5$ we get .... $F_{12}O_3(SO_4)_{15}$
Subtract from this .... Fe_2O_3

We have left .... $Fe_{10}(SO_4)_{15}$
Or .... $5Fe_2(SO_4)_3$.

In other words, five molecules of ferric sulphate and one molecule of ferric oxide give three molecules of ferric subsulphate.

Both solutions—of ferric subsulphate and of ferric tersulphate—are made from ferrous sulphate—just as ferric chloride was made from ferrous chloride—by oxidation with nitric acid, the reaction in making ferric tersulphate being:

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 = 3Fe_2(SO_4)_3 + N_2O_2 + 4H_2O.$$

Compare this to the equation in making subsulphate, viz.:

$$12FeSO_4 + 3H_2SO_4 + 4HNO_3 = 3Fe_4O(SO_4)_5 + 2N_2O_2 + 5H_2O.$$

This shows that while three molecules of sulphuric acid are used in both reactions, that quantity suffices for six molecules of ferrous sulphate in making the tersulphate, and for twelve molecules of ferrous sulphate when the subsulphate is made. In other words, in making the tersulphate from a given quantity of ferrous sulphate, twice as much sulphuric acid is required as is needed to make the subsulphate. The N_2O_2 of the equations just given is a colorless gas, which on coming in contact with the air is instantly converted into N_2O_4, which we met in the sulphuric acid manufacture and which form the red fumes spoken of in the pharmacopœial process.

Note that Monsel's solution—the *sub*sulphate—is to be dispensed when the *per*sulphate is called for.

As just mentioned above, the solution of subsulphate of iron differs from the solution of tersulphate of iron in that it is made from less sulphuric acid and more ferrous sulphate. This is best shown by a comparison of the quantities of the ingredients of the two solutions:

	FERROUS SULPHATE	SULPHURIC ACID	
Solution of tersulphate.........	500 Gm.	96 Gm.	to 1000 Gm. finished product.
Solution of subsulphate	675 Gm.	65 Gm.	

One of the simplest tests of distinction between the two solutions is the behavior of each when treated with an equal quantity of concentrated sulphuric acid. Under such treatment the subsulphate forms a semisolid mass, while the tersulphate forms a clear, limpid liquid.

The solution of subsulphate of iron is a favorite styptic and astringent, used for staunching the flow of blood, and is rarely given internally. The residue from the evaporation of the solution, termed *Monsel's powder* in commercial usage, is very largely used for this purpose, especially in barber shops for the drying up of cuts produced in shaving.

Dose.—0.2 mil (3 minims).

Liquor Ferri Oxysulphatis (N.F.) is a solution of ferrous sulphate oxidised with nitric acid without addition of extra sulphuric acid.

Magma Ferri Hydroxidi (N.F.), or *ferri hydroxidum* (U.S.P. VIII), is ferric hydroxide $Fe(OH)_3$ and is produced by pouring a diluted solution of ferric sulphate into a diluted ammonia water; the equation showing the reaction being

$$Fe_2(SO_4)_3 \quad + \quad 6NH_4OH \quad = \quad 2Fe(OH)_3 \quad + \quad 3(NH_4)_2SO_4.$$

It is a red-brown, thick, tenacious precipitate, called a "magma," already mentioned (p. 145).

In making this preparation, it is very important that the tersulphate solution be added to the diluted ammonia. If the reverse operation is performed, we obtain an oxyhydrate rather than the hydroxide itself.

Since ferric hydroxide very rapidly decomposes into water, and ferric oxide, which is insoluble even in acids, it must be freshly prepared when wanted, and since when needed for poisoning with arsenic, it must be dispensed with the least possible loss of time, every pharmacist should keep on hand diluted solutions of ammonia water and of ferric sulphate. Moreover, in order to expedite matters, it is advisable to place convenient to the bottles holding these two solutions strainers and their required paraphernalia. Since the dispensing of these preparations for poisoning by arsenic, fortunately, does not occur every day, this outfit may rest on the shelf for years without being used. Such being the case, it is advisable to renew, from time to time, the diluted ammonia water. The diluted solution of ferric sulphate keeps perfectly. When dispensed as an antidote for arsenic poisoning, haste is the prime requirement, and hence the pharmacist need not bother about washing the precipitate completely free from the ammonium sulphate. All that is necessary is to free the magma from ammonia water. In practice it is best to prepare rapidly a small quantity of the magma, say, one or two ounces, in a very incomplete way, and despatch this to the sufferer with the promise of an additional quantity to be sent later on. However, for the purpose of an antidote for arsenic *ferric hydroxide with magnesia* (p. 516) is preferred.

For chemical purposes, such as for the manufacture of scale salts and the detannating of pharmaceuticals, the ferric hydroxide so employed should be totally free from ammonium sulphate. The process of washing the precipitate is very tedious. The writer, for such purposes, throws the magma on large canvas strainers of texture sufficiently coarse to permit the passage of water. Through such strainers, however, a considerable quantity of the magma is apt to escape at first, and in order that none of this be lost, the strainers are arranged in a rack, so that tiers of at least three such strainers are employed. In this way the magma passing through the top strainer had a chance to collect on the second strainer, and that which passed through the second strainer was almost sure to be retained by the third one. Beneath the third strainer a suitable receptacle for collecting the drippings was placed. After the precipitate, with its supernatant liquor, had been transferred to the strainers, the wash-water was introduced into the top strainer by means of a siphon, so regulated that the amount of water dripping through exactly replaces the amount of water dripping therefrom.

In this way large quantities of magma can be readily washed within twelve to eighteen hours.

Ferric hydroxide was introduced into medicine by reason of its value as an antidote for arsenic, the discovery of this property being made by Bunsen and Berthold in 1834. The chemical reason of the efficiency of the hydroxide for this purpose is very simple, being due to the formation of the insoluble ferric arsenite, as shown in the following equation:

$$3As_2O_3 \quad + \quad 2Fe(OH)_3 \quad = \quad 2Fe(AsO_2)_3 \quad + \quad 3H_2O.$$

For antidotal purposes it is administered in tablespoonful doses, followed by an emetic, and, as mentioned above, the ferric hydroxide with magnesia is now considered preferable.

Pharmaceutically, ferric hydroxide is the basis of the scale preparations of iron.

Dialyzed iron is an unofficial modification of ferric hydroxide, and has already been discussed as a type of the products of dialysis (p. 154).

This preparation was originally made by treating solution of ferric chloride with freshly precipitated ferric hydroxide. It is now usually made by treating solution of ferric chloride with ammonia water. The mixture is placed on the dialyzing membrane, when crystalline substances, ammonium chloride and ferric chloride, pass through the septum, leaving colloidal ferric oxychloride, of composition varying from Fe_2Cl_6, $11Fe_2O_3$ to Fe_2Cl_6, $31Fe_2O_3$. Physical chemists consider it a colloidal solution of ferric hydroxide.

Dialyzed iron is a limpid, red-brown liquid, free from acidity and without styptic taste. It is used as a tonic in doses of 5 to 30 drops.

FERRI HYDROXIDUM CUM MAGNESII OXIDO—Ferric Hydroxide with Magnesium Oxide

(**Ferr. Hydrox. cum Mag. Oxid.**—Arsenic Antidote. Ferric Hydrate with Magnesia)

Condensed Recipe.

Mix 40 mils of solution of ferric sulphate with 125 mils of water; and keep it in an appropriate bottle. Triturate 10 Gm. magnesium oxide with enough water to make a thin paste and keep it in a liter bottle, adding enough water to make paste measure about 750 mils. On call add the ferric solution to the well-shaken paste and then dispense. The magnesium oxide may be replaced by 300 mils of magnesia magma. For details see U.S.P., p. 168.

It will be seen that this preparation is made by treating diluted solution of ferric sulphate with the milk of magnesia (that is, magnesia rubbed with water), the reaction being:

$$2Fe_2(SO_4)_3 + 6Mg(OH)_2 = 4Fe(OH)_3 + 6MgSO_4.$$

The result of this reaction, as will be noticed, is practically the same as in the method of making pure ferric hydroxide. The great advantage, however, is that the magma thus produced is efficient without washing, because the impurities are the mild alkali, magnesium hydroxide, and the harmless magnesium sulphate. These two compounds also serve antidotal purposes by reason of the formation of the insoluble magnesium arsenite. For this reason this preparation is greatly to be preferred over the pure ferric hydroxide as an antidote for arsenic, it being rapidly prepared by the blending of the diluted solution of ferric sulphate with a magnesia mixture, followed by the rapid removal of the superfluous water by straining. The pharmacopœia directs that the diluted solutions of ferric sulphate and the milk of magnesia should be kept on hand by the pharmacist, for instant admixture in cases of arsenical poisoning.

Dose.—Arsenical antidote, 120 mils (4 fluidounces).

Ferri Oxidum Saccharatum (N.F.) is made by preparing ferric hydroxide from ferric chloride and sodium carbonate, mixing the washed magma with sugar dissolving the mixture in a 15 per cent. solution of sodium hydroxide and then evaporating the solution to dryness on a water-bath. It contains 2.8 per cent. of iron.

LIQUOR FERRI ET AMMONII ACETATIS—Solution of Iron and Ammonium Acetate

(**Liq. Ferr. et Ammon. Acet.**—Basham's Mixture)

Condensed Recipe.

Mix together in order named, 500 mils of a slightly acid, solution of ammonium acetate, 60 mils of diluted acetic acid, 40 mils of tincture of ferric chloride, 120 mils of aromatic elixir, 120 mils of glycerin and enough distilled water to make 1 liter.

Summarized Description.

Clear, reddish-brown liquid; sweetish saline then slightly astringent taste; aromatic odor; sp. gr. 1.039. For details see U.S.P., p. 242.

For *tests for identity*, see U.S.P.

Remarks.—In mixing the chemicals as above described, ferric acetate is produced, and a brilliant garnet solution ensues. In preparing the solution, it is important that the full amount of acetic acid be employed, for if the solution is not distinctly acid, the basic acetate of iron will separate as an unsightly red-brown precipitate.

The same precipitate occurs in a properly prepared solution, when it becomes old, hence the pharmacopœial direction as to preparing freshly.

Basham's mixture, as this solution is called, is a popular tonic in some sections.

Dose.—15 mils (4 fluidrachms).

Solution of Ferric Acetate (U.S.P. 1890; N.F. IV).—This preparation, containing 31 per cent. of the anhydrous salt, is made by dissolving freshly prepared ferric hydroxide in the molecular quantity of glacial acetic acid.

The solution of ferric acetate is used as a mild chalybeate tonic, and in doses of 2 to 10 minims.

Solution of Ferric Nitrate (U.S.P. 1890; N.F. IV).—This preparation, containing 1.3 per cent. metallic iron, is made by a process very similar to that used in making the solution of ferric acetate; the ferric hydroxide in this case being dissolved in the molecular quantity of nitric acid. This solution is interesting by reason of the light tint which it possesses; most of the other ferric solutions are of a brilliant garnet-red, but this one usually possesses a color scarcely darker than amber.

Solution of Ferric Citrate (U.S.P. 1890; N.F. IV).—Recipe and details of manufacture in Part VII.

This solution, like the two just discussed, is made by treating ferric hydroxide with an appropriate acid; in this case, citric acid. If to the drained magma crystals of citric acid are added, and the mixture placed on a water-bath for a few minutes, the magma is converted into a clear garnet-red solution, usually weaker than the pharmacopœial strength. It is, therefore, evaporated on a water-bath at a temperature not exceeding 60°C. This shows that a large amount of water is mechanically held by the ferric hydroxide, its absorbing capacity being almost as great as that of aluminum hydroxide.

The solution of ferric citrate affords a convenient liquid form of that valuable remedy—ferric citrate. It contains about 50 per cent. of ferric citrate, and will be found of great convenience in dispensing in prescriptions directing ferric citrate dissolved in water, since the dissolving of ferric citrate is quite tedious.

THE SCALE SALTS OF IRON

Having discussed the official ferrous and ferric salts, we can now consider the third group of official iron compounds—the scale preparations of iron.

These preparations are not always definite chemicals; thus, the official soluble ferric pyrophosphate is a mixture of pyrophosphate of iron, which in pure form is an insoluble green-gray powder, and sodium citrate, with traces of sodium pyrophosphate and ferric citrate. The scale preparations are bright, shining fragments, which are not crystals, despite an impression to that effect, arising no doubt from a brand of scale pepsin on the market termed "crystal pepsin."

Crystals are bodies having definite geometric form, and any examinations of a scale preparation, no matter how superficial, will prove absence of distinct unvarying form. Preparations are scaled just as molasses candy is made—by concentrating to a thick syrup and pouring this on a smooth hard surface, usually on sheets of glass.

All scale preparations of iron are made directly or indirectly from ferric hydroxide, that red-brown magma formed by adding solution of ferric sulphate to a diluted water of ammonia.

If we treat the magma with citric acid, ferric citrate is formed; if tartaric acid be the acid added, we get ferric tartrate; while if we use acid potassium tartrate (potassium bitartrate), iron and potassium tartrate will be the product.

All the official scale preparations of iron save the last two mentioned are made from ferric citrate; hence we will discuss those two first, and then have clear sailing for those owing their existence to ferric citrate.

Ferri et Ammonia Tartras (U.S.P. VIII), or *iron and ammonium tartrate*, is prepared by adding ferric hydroxide to a solution of ammonium tartrate and tartaric acid, evaporating to syrupy consistence, and pouring on plates of glass. As the last part of the process—evaporating and pouring on plates of glass—is common to all scale preparations, we will, for brevity's sake, call it scaling in future. Like all other scaled iron salts, the product is a tonic. Its dose is 4 grains.

Ferri et Potassii Tartras (U.S.P. VIII), or *iron and potassium tartrate*, is prepared like iron and ammonium tartrate. In the latter the ferric hydroxide is treated with what may be considered a solution of ammonium bitartrate, whereas in the iron and potassium tartrate the magma is dissolved by treating with potassium bitartrate or cream of tartar. This fact is worth passing notice, inasmuch as it clearly shows that acid salts possess acid properties; that is, that the hydrogen found in acid salt is capable of combining with a metal, just as does the hydrogen with the acid from which it is derived.

A commercial form of iron and potassium tartrate formerly enjoyed large popularity. This was the chemical in the form of an oval lump, to one end of which was attached a loop of string or ribbon. This form was formerly highly esteemed in France under the name of "*boule de Mars.*" This name, by the way, suggested the alchemistic title of the element iron, which was called, by the forerunners of chemistry, after the god of war, Mars. Another survival of the alchemistic name of iron is shown in the words "*crocus Martis.*" The "*boule de Mars*" was supposed to be carried around by the patient, and when a chalybeate tonic was desired, the lump was suspended into a glass of water or wine, and after sufficient immersion it was supposed that a sufficient quantity of the chemical would be dissolved in the fluid, thus producing a pleasant tonic.

Iron and potassium tartrate is used as a tonic, in 4-grain doses.

Ferri Citras (U.S.P. VIII), or *ferric citrate*, is made by evaporating a solution of ferric citrate at a temperature not higher than 60°C. to a thin syrup, and then scaling this by pouring it on a glass plate. Its preparation is described in detail in Part VII.

Ferric citrate is very soluble in water; its solution, however, takes place very slowly, as is also true of most of the scale salts of iron.

In dissolving these salts they should never be reduced to powder, nor is it advisable to triturate in a mortar with a solvent. The solution is effected far more rapidly by pouring the scale salts upon the full amount of solvents contained in a bottle and vigorously shaking.

But even thus, the solution of the salt, requires considerable patience, hence the use of a solution of ferric citrate is advisable wherever possible. The very fact that ferric citrate and other scale salts slowly dissolve renders them valuable for the manufacture of pills, because, when blended with an excipient, they are apt to retain their form, producing the pills that do not flatten.

Ferric citrate is a chalybeate tonic and is given in 4-grain doses.

FERRI ET AMMONII CITRAS—Iron and Ammonium Citrate

(Ferr. et Ammon. Cit.—Soluble Ferric Citrate–Ammonio-ferric Citrate)

Iron citrate rendered more readily soluble by the presence of ammonium citrate and containing not less than 16 per cent. nor more than 18 per cent. of Fe. Preserve it in well-closed containers, protected from light.

Summarized Description.

Thin, transparent, garnet-red scales; saline, mildly ferruginous taste; somewhat deliquescent; completely soluble in water; insoluble in alcohol; chars on heating, leaving ferric oxide. For details see U.S.P., p. 167.

For *tests for identity*, for *impurities* (ferric citrate, tartrate) and for *assay* see U.S.P., p. 167 and also Part V of this book.

Remarks.—Ferric citrate is very slowly soluble in cold water; hence a more soluble form, made by adding ammonia water to solution of ferric citrate and scaling, is the one chosen for inclusion in the pharmacopœia. It is a curious fact that while ammonia water precipitates the crystalline ferrous and ferric salts, it simply darkens and renders more soluble the scale preparations. Cowley claims that iron and ammonium citrate is a true salt having the formula $(NH_4)_3Fe(C_6H_5O_7)_2$.

While ferric citrate occurs in garnet-red scales, the scales of iron and ammonium citrate are yellow-brown. Like the other scale salts of iron it is a tonic.

Dose.—250 milligrammes (4 grains).

FERRI ET QUININÆ CITRAS—Iron and Quinine Citrate

(Ferr. et Quin. Cit.—Ferri et Quininæ Citras Solubilis, U.S.P. VIII, Soluble Iron and Quinine Citrate)

Iron citrate and quinine citrate rendered more soluble by the presence of ammonium citrate and containing not less than 11.5 per cent. of anhydrous quinine ($C_{20}H_{24}O_2N_2$) and not less than 13 per cent. of Fe. Preserve it in amber-colored, well-stoppered bottles, protected from light.

Summarized Description.

Thin, transparent, deliquescent, greenish or golden-yellow scales; bitter, mildly ferruginous taste; completely soluble in cold water; partly soluble in alcohol; chars on heating, leaving a residue of ferric oxide. For details see U.S.P., p. 167.

For *tests for identity,* for *impurities* (tartrates) and for *assay* see U.S.P., p. 168 and also Part V of this book.

Remarks.—No process for the manufacture of this salt is given by the present pharmacopœia. The pharmacopœia of 1890 directed its manufacture by adding citric acid and the uncombined alkaloid, quinine, to a solution of ferric citrate, and then scaling the resulting liquid.

The dried scales are of a reddish-brown tint.

This is important because of the fact that a very large amount of the commercial iron and quinine citrate possesses a yellowish-brown tint, and is none other than soluble iron and quinine citrate.

For practical purposes the latter preparation may be preferable to the official iron and quinine citrate, but the point at issue is that if a physician prescribes iron and quinine citrate, the soluble iron and quinine citrate should not be dispensed. The very fact that the iron and quinine citrate is slowly soluble renders it preferable to the soluble iron and quinine citrate, because the more slowly soluble a bitter compound is, the less does it affect the palate of the patient.

It will be noticed that this official compound is directed to contain 11.5 per cent. of dried quinine, and that a process of assaying the same is given in the pharmacopœia. An assay of the amount of iron is also given in the pharmacopœia, which directs that it contain 13 per cent. of the metal.

Iron and quinine citrate, like all the scale salts, is a tonic.

Dose.—250 milligrammes (4 grains).

Ferri et Strychninæ Citras (U.S.P. VIII), or *iron and strychnine citrate,* is made by adding a solution of the alkaloid strychnine, in citric acid, to a solution of iron and ammonium citrate.

It is important to note that in making the iron and quinine citrate and iron and strychnine citrate, the uncombined alkaloid is used with the citric acid, and not one of its salts.

By reason of containing the poison strychnine the dose of iron and strychnine citrate is somewhat less than that of the other scale salts, being about 2 grains.

FERRI PHOSPHAS—Ferric Phosphate

(**Ferr. Phos.**—Ferri Phosphas Solubilis, U.S.P. VIII, Soluble Ferric Phosphate)

Ferric Phosphate rendered soluble by the presence of sodium citrate. It contains not less than 12 per cent. of Fe. Preserve it in amber-colored, well-stoppered bottles, protected from light.

Summarized Description.

Thin, bright green, transparent scales; acidulous, slightly saline taste; permanent in dry air and in the dark, but becomes discolored on exposure to light, completely soluble in water; insoluble in alcohol. For details see U.S.P., p. 169.

For *tests for identity*, for *impurities* (ammonia, pyrophosphate) and for *assay* see U.S.P., p. 169 and also Part V of this book.

Remarks.—While no recipe is given in the present pharmacopœia, for the manufacture of this salt, the pharmacopœia of 1890 directed that it be made by mixing solution of ferric citrate with a solution of sodium phosphate and then scaling the resulting fluid.

Ferric phosphate in the pure form is insoluble, but the mixed product resulting from the combination of ferric phosphate with alkaline citrates is soluble. Hence this official is not a definite compound but is a mixture of sodium citrate with ferric phosphate and may be called sodioferric citrophosphate.

These compounds differ from the other scale salts of iron, first, in being an indefinite chemical and, secondly, by reason of the characteristic green color of the scales. It is highly esteemed as a tonic.

Dose.—250 milligrammes (4 grains).

Ferri Pyrophosphas (U.S.P. VIII; N.F. IV), or *soluble ferric pyrophosphate*, is an indefinite mixture of sodium citrate with ferric pyrophosphate. It should contain not less than 10 per cent. of metallic iron and is used as a tonic in 4-grain doses.

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CHAPTER XXXII

ARSENIC, ANTIMONY, TIN, GOLD, AND PLATINUM

ARSENIC

Symbol, As. Atomic weight, approximately 75

THE chief ores from which this element is derived are *realgar*, As_2S_2, *orpiment*, As_2S_3; the latter word, a corruption of "auri pigmentum," which, translated, means the color of gold or of fire, so-called because of its brilliant yellow tint. Another ore of arsenic—*flowers of arsenic* or *white arsenic*—As_2O_3, is mined in certain districts of Styria, where the natives become habituated to its use and thus are immune from its poisonous action.

Arsenic has been known from comparatively early times. The red and yellow sulphides were known to the Greek writers. The white arsenic appears to have been known to Geber in the eighth century. In the eleventh century Avicenna differentiated between the white arsenic and the red and yellow. Albertus Magnus, in the thirteenth century, appears to have isolated the element, and the practical separation was a matter of technic in the seventeenth century.

The word arsenic is derived from the Greek word *arsenikon*, which was the term used to designate the ore orpiment. The *metallurgy* of arsenic is somewhat similar to that of the other elements which we have considered, it being isolated by heating the oxide with coal, as shown in the following equation:

$$As_2O_3 + C_2 = As_2 + CO + CO_2.$$

This process is not used much now, since native arsenic oxide is comparatively rare, and most of the element is made by heating arsenical iron, and from mispickel, when arsenic is freed and sublimes. The respective reactions are:

$$Fe_3As_4 + \text{heat} = Fe_3As_2 + As_2.$$
$$Fe_2As_2S_2 + \text{heat} = 2FeS + As_2.$$

Metallic arsenic occurs in the form of crystalline masses, which are steel gray when freshly sublimed, but becoming dull and black on exposure to air. Besides this crystalline form, amorphous forms are known.

Arsenic and antimony, like zinc and aluminum, form a group about midway between the metals and the non-metals, and the non-metallic character of arsenic and antimony is even more strikingly demonstrated than in the case of zinc and aluminum. In fact, the most abundant compound of arsenic is one in which arsenic shows its negative character, namely, in arsenic trioxide (arsenous acid, U.S.P. 1890). But, while showing many points in common with the non-metallic elements, its metallic properties are well defined. Thus, it is precipitated with hydrogen sulphide, as are the other metals of this group, and combines with acids to form the salts of arsenic, such as arsenic chloride and arsenic iodide.

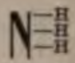
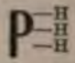
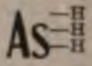
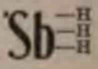
On the other hand, when combined with alkalies the negative side is clearly demonstrated, and among the official compounds we find solution of potassium arsenate and sodium arsenate.

The **tests** for arsenic are as follows: The yellow sulphide (orpiment), produced when hydrogen sulphide is passed through an acidulated solution of arsenous acid. Silver nitrate test solution produces a yellow precipitate of silver arsenite or a brown precipitate of silver arsenate, according to the valence of the arsenic in the suspected solution. A characteristic test for arsenic is the so-called *cacodyl reaction*, which is brought about by fusing the arsenic with potassium or sodium acetate, when a disgusting odor of cacodyl is produced; for details descriptive of this organic compound, see p. **603**. The equation is:

$$As_2O_3 + 4KC_2H_3O_2 = [As(CH_3)_2]_2O + 2K_2CO_3 + 2CO_2.$$

Compounds of arsenic, treated with copper sulphate and ammonia, yield a characteristic green precipitate of copper arsenite. This green insoluble substance was formerly largely used in the technic under the name of *Scheele's green*, as a coloring-matter. The danger of this body however, has caused it to fall more or less into disuse.

Arsenic was formerly largely employed by poisoners, and accordingly many tests have been devised for the detection of the element, such as the tests suggested by Marsh, Fleitmann, Gutzeit, and Reinsch. The principle of action of the first three of these is based on the formation of the gas, hydrogen arsenide, AsH_3, which is produced by the union of hydrogen (generated by action of sulphuric acid on zinc), with arsenic in the suspected substance, forming hydrogen arsenide, AsH_3, which is analogous to ammonia, NH_3; to phosphine (phosphoretted hydrogen, PH_3), that spontaneously combustible gas mentioned on p. 421, and to antimoniuretted hydrogen (stibine, SbH_3), mentioned a little further along These four gases can best be compared in tabulated form:

Nitrogen,	valence	III	gives	ammonia,	NH_3,	graphically	
Phosphorus,	"	III	"	phosphine,	PH_3,	"	
Arsenic,	"	III	"	arsine,	AsH_3,	"	
Antimony,	"	III	"	stibine,	SbH_3,	"	

Hydrogen burns to pure water ($H_2 + O = H_2O$), while AsH_3, in burning, yields water and metallic arsenic ($2AsH_3 + 3O = 3H_2O + As_2$); the latter separates as an arsenic spot on a piece of porcelain, just as the carbon in gas separates as soot when burned in a fish-tail burner. The details of Marsh's test is beyond the limits of this work, and the reader is referred to some book on analytic chemistry.

Mention, however, must be made of the fact that antimony compounds treated with nascent hydrogen produced from zinc and sulphuric acid form antimoniureted hydrogen, SbH_3, which, on burning, likewise deposits a stain on a porcelain dish. This latter stain is, however, brown black, and is not soluble in Labarraque's solution, as is the arsenic spot. Marsh's test is no longer given in the pharmacopœia, being replaced by a modification which does away with the cumbersome apparatus used in Marsh's test. This modification is *Gutzeit's test*, in which the hydrogen is developed from zinc and sulphuric acid in a test-tube, and the suspected substance added. If arseniuretted hydrogen forms, it blackens the cap of filter-paper moistened with silver nitrate solution, covering the open end of the tube. Like Marsh's test, this responds when antimony is present, and, therefore, a preferable test is that of *Fleitmann*, in which the hydrogen is not developed by action of acid on zinc, but by treating zinc with potassa, the reaction being:

$$3Zn + 6KOH = 3K_2ZnO_2 + 3H_2.$$

Then,

$$3H_2 + As_2 = 2AsH_3.$$

In this reaction antimony will not take part, even if present, and therefore nothing but arsenic can be detected by this means. The detection of the arsenic in this case is identical with that in Gutzeit's test, by the blackening of silver nitrate.

Reinsch's test is produced by placing a sheet of bright metallic copper into the suspected solution. If arsenic be present, an electrolytic action takes place, with the deposition of that element on the copper plate, which accordingly becomes blackened. *Bettendorf's test* consists in dissolving arsenic in concentrated hydrochloric acid, adding solution of stannous chloride, and introducing into the test-tube containing this mixture a piece of tin-foil. If arsenic be present, a brown coloration takes place.

In experimenting with Marsh's test, the operator should be careful regarding the inhaling of the vapors produced, as the hydrogen arsenide vapors are very poisonous, the chemist Gehlen having been killed by this substance during experiments in 1815. It has been noted that wall-paper colored green by the use of Scheele's green produces symptoms of arsenical poisoning in persons in the room. The exact reason for this is not clearly defined, but at the present time it is considered to be due to the formation of AsH_3, through the action of moisture on the walls with the arsenical color and inhalation of the gas by the occupants of the room.

Arsenic, like nitrogen and phosphorus, exhibits the valence III and V, as shown in two oxides—As_2O_3 and As_2O_5—which are called arsenous and arsenic oxides respectively.

The official preparations of arsenic are:

Arsenic trioxide. At least 99.8 per cent. absolute As_2O_3.

Solution of arsenous acid, containing from 0.975 to 1.025 per cent. arsenic trioxide.

Solution of potassium arsenite, containing from 0.975 to 1.025 per cent. arsenic trioxide.

Sodium arsenate. At least 99 per cent. absolute $Na_2HAsO_4 + 7H_2O$.

Exsiccated sodium arsenate. At least 98 per cent. absolute Na_2HAsO_4.

Solution of sodium arsenate, containing from 0.925 to 1.025 per cent. exsiccated sodium arsenate.

Arsenous iodide. At least 99 per cent. AsI_3.

Solution of arsenous and mercuric iodides, containing from 0.95 to 1.05 each of arsenous iodide and of mercuric iodide.

ARSENI TRIOXIDUM—Arsenic Trioxide

(**Arsen. Triox.**—Arsenous Acid—Arsenous Oxide—White Arsenic)

It contains, when dried to constant weight at 100°C., not less than 99.8 per cent. of As_2O_3 (197.92).

Summarized Description.

Opaque, white powder, or amorphous, transparent, glass-like masses, or crystalline, opaque, porcelain-like masses; in moist air the glassy variety changes to the opaque; soluble in water (glassy variety more than the crystalline) and in glycerin; slightly soluble in alcohol and ether; soluble in hydrochloric aid and in alkaline solutions; volatilizes on heating, subliming to transparent octahedral crystals; heated with charcoal, in a tube metallic arsenic sublimes and deposits as a mirror. For details see U.S.P., p. 64.

For *tests for identity*, for *impurities* (antimony, tin, cadmium) and for *assay* see U.S.P., p. 65 and also Part V of this book.

Remarks.—This most important of the official arsenical preparations, called arsenous acid by the pharmacopœia of 1890, is more properly termed arsenic trioxide by U.S.P. IX, since it is the anhydride As_2O_3, the true acid being produced only when the official substance is dissolved in water:

$$As_2O_3 + 3H_2O = 2H_3AsO_3.$$

Hence the aqueous solution still retains as official name the phrase, liquor acidi arsenosi.

Arsenic trioxide is prepared by the roasting of arsenical ores, when the oxide which is formed sublimes and is caught in appropriate condensing chambers. It is then purified by resublimation.

Arsenic trioxide acts as a reducing agent, being oxidized by potassium permanganate, and converting iodine into hydriodic acid. This explains the volumetric estimation of the chemical by means of a decinormal iodine solution. (See p. 897.) A volumetric estimation of the chemical can also be effected by use of decinormal permanganate solution.

Arsenous acid is a valuable alterative. Applied in the form of a powder, it acts as an escharotic, and for this purpose was formerly employed for the dusting of cancerous growths. Its action in this way, however, was dangerous, and at present it is now rarely so used.

Many of the largely advertised rat-poisons consist of arsenous oxide, either free or admixed. The antidote for such nostrums is, therefore, the same as that for arsenous oxide, namely, ferric hydroxide or ferric hydroxide with magnesia. (See p. 516.)

Dose.—2 milligrammes ($\frac{1}{30}$ grain).

LIQUOR ACIDI ARSENOSI—Solution of Arsenous Acid

For recipe see p. 185.

This is a 1 per cent. aqueous solution of arsenic trioxide, containing a sufficient quantity of hydrochloric acid to insure a complete solution. In the Pharmacopœia of 1870 it was styled the *solution of arsenous chloride*, but investigations have shown that the hydrochloric acid, in this case, acts merely as a solvent, not converting the oxide into chloride.

Dose.—0.2 mil (3 minims).

LIQUOR POTASII ARSENITIS—Solution of Potassium Arsenite

(**Liq. Pot. Arsen.**—Fowler's Solution. Liquor Arsenicalis. Liquor arsenicalis Fowleri P.I.)

An aqueous solution containing potassium arsenite, corresponding in amount to not less than 0.975 per cent. nor more than 1.025 per cent. of As_2O_3 (197.92). Preserve the Solution in amber-colored bottles.

Condensed Recipe.

Boil 10 Gm. arsenic trioxide and 20 Gm. potassium bicarbonate in a tared vessel with 100 Gm. distilled water until the solids are dissolved. Then add enough distilled water to make 970 Gm. and 30 Gm. compound tincture of lavender and, finally, filter. For details see U.S.P., p. 251.

Summarized Description.

Clear or faintly opalescent, pink liquid; lavender oil odor; alkaline reaction. For details see U.S.P., p. 251. For *tests for identity*, for *impurities* (arsenate) and for *assay*, see U.S.P., p. 251 and also Part V of this book.

Remarks.—This preparation, commonly called "Fowler's solution," is made from arsenic trioxide and potassium bicarbonate, colored with compound tincture of lavender. It contains 1 per cent. of arsenic trioxide.

The equation for its manufacture is either—

$$4KHCO_3 + As_2O_3 + 3H_2O = 2K_2HAsO_3 + 4H_2O + 4CO_2$$

or

$$2KHCO_3 + As_2O_3 = 2KAsO_2 + 2CO_2 + H_2O.$$

The pharmacopœia directs that the potassium bicarbonate and the arsenic trioxide be boiled together in water to insure chemical combination. If a solution of potassium bicarbonate and a solution of arsenic trioxide are mixed together in the cold, no reaction takes place, and, in fact, some authorities claim that even boiling produces but a slight effect on the two constituents. How little decomposition occurs is shown by the fact even when twice the amount of arsenous acid is boiled with solution of potassium bicarbonate, and even when such solution is boiled to dryness and then redissolved in water, the latter liquid still effervesces with acids.

Despite this fact, some authorities claim that a meta-arsenite of potassium ($KAsO_2$) is produced; while others hold to the ortho-arsenite formula. K_2HAsO_3; this is supposedly the acid potassium salt of H_3AsO_3. Fowlers solution is one of the most popular of arsenical preparations, being particularly esteemed as an alterative in cases of malaria. Many physicians in malarial countries consider this preparation almost in the light of a specific.

Dose.—0.2 mil (3 minims).

SODII ARSENAS—Sodium Arsenate

(**Sod. Arsen.**—Arsenas sodii P.I.)

It contains not less than 58.98 per cent. nor more than 61.92 per cent. of anhydrous sodium arsenate (di-sodium ortho-arsenate), corresponding to not less than 99 per cent. of the crystallized salt [$Na_2HAsO_4 + 7H_2O = 312.08$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, transparent, monoclinic prisms, efflorescent in dry air, deliquescent in noist air; very poisonous; soluble in about 1.5 parts of water; slightly soluble in alcohol; n heating is first exsiccated and is then converted into pyroarsenate. For details ee U.S.P., p. 381.

For *tests for identity*, for *impurities*, see exsiccated sodium arsenate.

Remarks.—Sodium arsenate is made by adding arsenous acid to the mixture of sodium carbonate (or sodium hydroxide) and sodium nitrate, and heating same to redness and pouring out the fused mass on a slab, and treating it with boiling water as soon as solidified. The solution is then evaporated until crystallization takes place; the crystals are removed from the mother liquor and dried according to the usual method.

This process furnishes an interesting example of oxidation. Arsenic has the valence III and V, and the two oxides, As_2O_3 and As_2O_5, when treated with water, yield respectively the true arsenous acid (H_3AsO_3) and arsenic acid (H_3AsO_4), the latter being analogous to phosphoric acid, H_3PO_4. (See p. 359.) An arsenate is a salt of arsenic acid, and if we treat sodium carbonate with arsenous acid (which is common, while arsenic acid is rare), we would not get an arsenate, but an arsenite, just as we did in Fowler's solution.

It will be noticed that the arsenical ingredient used above is arsen*ous* oxide (As_2O_3). We have already learned (p. 359) that "ous" acids give "ite" salts, a proof of which, with the very acid we are now considering, is shown in Fowler's solution—liquor potassii arsenitis—where we see that arsenous acid, cooked with potassium bicarbonate, yields potassium arsen*ite*—not the arsen*ate*—shown in equation "a" given on p. 525.

In exactly similar manner sodium carbonate and arsenous acid yield Na_2HAsO_3, sodium arsen*ite*. Necessary to form the arsen*ate*, is arsen*ic* acid, As_2O_5 or H_3AsO_4, and, accordingly, if we start out with arsenous acid, it must be oxidized to arsenic acid before the arsenate can be formed. It may be recalled that in making sulphuric acid, sulphur*ous* oxide, SO_2, was oxidized to sulphur*ic* oxide, SO_3, and that the oxidation was accomplished by nitric acid. In oxidizing arsenous oxide to arsenic oxide in the manufacture of sodium arsenate nitric acid is not adapted, since it, rather than the arsenic preparation, would react with the sodium carbonate, the final product being a mixture of sodium nitrate and arsenic acid; hence we employ sodium nitrate, $NaNO_3$, which at a high heat splits in a manner akin to nitric acid itself, with the liberation of oxygen.

The usually accepted equation of manufacture—

$$(a)\ Na_2CO_3 + As_2O_3 + 2NaNO_3 = Na_4As_2O_7 + N_2O_3 + CO_2,$$
$$(b)\ Na_4As_2O_7 + H_2O = 2Na_2HAsO_4,$$

is more complex than the explanation just given, because of the presence of an intermediate product, sodium pyroarsenate, $Na_4As_2O_7$. This body, however, is analogous to sodium pyrophosphate, $Na_4P_2O_7$, the latter a salt of pyrophosphoric acid, $H_4P_2O_7$, the chemistry of which was explained on p. 441.

Sodium arsenate is used as an alterative and tonic.

Dose.—5 milligrammes (1/12 grain).

SODII ARSENAS EXSICCATUS—Exsiccated Sodium Arsenate (Sod. Arsen. Exsic.)

It contains, when dried to constant weight at 150°C., not less than 98 per cent. of Na_2HAsO_4 (185.97). Preserve it in well-closed containers.

Condensed Recipe.

Allow crystalline sodium arsenate to effloresce between 40° and 50°C., then heat at 150° until the product ceases to lose weight. For details see U.S.P.

Summarized Description.

Amorphous, slightly hygroscopic, white powder; very poisonous; soluble in about 3 parts of water; slightly soluble in alcohol. For details see U.S.P., p. 382.

For *tests for identity*, for *impurities* (arsenite, lead, copper, iron) and for *assay* see U.S.P., p. 382 and also Part V of this book.

Remarks.—This official is made by driving off the seven molecules of water of crystallization from the crystalline sodium arsenate by use of a temperature of 150°C. (302°F.).

It is used for making the official *solution of sodium arsenate.* While the exsiccated salt was not recognized by the Pharmacopœia of 1890, the solution of sodium arsenate of that pharmacopœia was prepared by first exsiccating the crystallized salt, experience showing that when that solution is prepared from the crystalline salt, it is of uncertain strength, since the crystals are usually more or less efflorescent.

Dose.—3 milligrammes ($\frac{1}{20}$ grain).

Liquor Sodii Arsenatis.—For recipe see p. 188.

This official is a 1 per cent. solution of exsiccated sodium arsenate in water.

Dose.—0.2 mil (3 minims).

Liquor Sodii Arsenatis, Pearson (N.F.). This solution (see p. 191) is only one-tenth the strength of the official solution of sodium arsenate.

Liquor Arsenicalis, Clemens (N.F.), or *Clemen's solution of arsenic,* is a solution of potassium arsenate and bromides, made by boiling together arsenic trioxide, potassium carbonate and water and then adding bromine to the cooled and diluted solution. It represents about 1 per cent. As_2O_3.

ARSENI IODIDUM—Arsenous Iodide

(**Arsen. Iod.**—Arsenic Iodide)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of AsI_3 (455.72). Preserve it in amber-colored, glass-stoppered vials, in a cool place, protected from light.

Summarized Description.

Orange-red, crystalline powder; stable when kept cool and protected from light; soluble in about 12 parts of water and in about 28 parts of alcohol; also soluble in chloroform, ether and carbon disulphide; does not lose iodine at water-bath heat, but volatilizes at higher temperatures; liberates iodine and nitrogen oxides when treated with nitric acid; fresh aqueous solution is colorless, but it turns yellow on standing. For details see U.S.P., p. 64.

For *tests for identity,* and for *assay* see U.S.P., p. 64 and Part V of this book.

Remarks.—This compound was formerly made by fusing molecular quantities of metallic arsenic and iodine into a test-tube and pouring the fused mass on a slab in order to permit it to solidify. This process, however, was very wasteful of the iodine, and therefore a much better method is by making a solution of iodine in carbon disulphide, and sprinkling therein finely powdered arsenic until the purple color is discharged.

Arsenic iodide is a comparatively unstable compound, losing its iodine by volatilization until its composition is very largely changed. It is, therefore, at its best a rather uncertain preparation, as is the case with sulphur iodide.

This substance is used as an alterative.

Dose.—5 milligrammes ($\frac{1}{12}$ grain).

LIQUOR ARSENI ET HYDRARGYRI IODIDI

For recipe see p. 186.

This official, commonly called *Donovan's solution,* after the originator, contains 1 per cent. of arsenous iodide and 1 per cent. of mercuric iodide.

The solution should be practically colorless. On standing, it assumes a reddish tint, and such a reddened Donovan's solution should not be dispensed. While some writers claim that the reddening is due to separation of free iodine, Huskisson points out that reddened solutions do not give the iodine reaction with starch paste. The change in color can be largely obviated by keeping a small amount of finely divided metallic arsenic or a globule of mercury in the solution; taking care to dispense only the clear supernatant fluid.

Donovan's solution is used as an alterative and tonic.

Dose.—0.1 mil (1½ minims).

It will be seen that the pharmacopœia recognizes four solutions containing arsenic compounds (see p. 188), and that, while all these are 1 per cent. preparations, all *do not* contain 1 per cent. of arsenic trioxide.

ANTIMONY

Symbol, Sb. Atomic weight, approximately 122

This element is sometimes found native in uncombined form, but its chief ore is the sulphide—Sb_2S_3—which is called stibnite.

The symbol Sb as applied to antimony, is derived from the Latin name of the element, *stibium*, which is in turn derived from the Greek word *stibi*, which was the name applied to that native sulphide, which has been known since classic times. The etymology of the word antimony has been explained by a curious fable, which relates that Basel Valentine, a monk of the monastery of Erfurt, experimented with the salts of this element on his brother monks, with fatal results, whereupon he named the element *antimoine*—against monks. This theory of the origin of the name, however, has been exploded since the word antimonium was used in a book of Constantine of Salerno (A. D. 1100), and merciless critics have even denied the existence of such a man as Basel Valentine. Suffice it to say that there appeared during the fifteenth century a book entitled "The Triumphant Chariot of Antimony," purported to have been printed from the manuscript of this monk Basel Valentine. It was through the publication of this work that the use of antimony in medicine became popularized. In the sixteenth and seventeenth centuries antimony and its compounds were among the most popular of medicines, the element being isolated by Boerhave. One of the applications of this substance was in the form of a cup made of this metal (*pocula emetica*). Acid or wine was allowed to stand in this cup until a certain amount of this metal had been dissolved. The wine, when drank, then acted as an emetic. Under the name of "*pilulæ perpetua*" small globules of the metal were used in the seventeenth century, enough of the metal being dissolved from the swallowed pill by the acid juices of the stomach to produce the desired effect. The pill, voided either by emesis or through the bowels, was then saved for the next need.

The metallurgy of antimony is accomplished by heating the sulphide with metallic iron, as shown in the following equation:

$$Sb_2S_3 + Fe_3 = 3FeS + Sb_2.$$

In order to facilitate the separation of the metal from the ferrous sulphide a mixture of exsiccated sodium sulphate and coal is added for the purpose of forming a slag with the ferrous sulphide.

Antimony is a brilliant brittle metal, of lamellated texture, and silvery white when chemically pure. The commercial antimony, however, is usually of a bluish-white tint. Antimony is a constituent of several valuable alloys. Thus, *type-metal* is a combination of 15 per cent. of antimony and 85 per cent. of lead; while *pewter* consists of 10 per cent. of antimony, 86 per cent. of tin, 3 per cent. of zinc, and 1 per cent. of copper.

The *tests* for antimony are as follows: hydrogen sulphide precipitates from acid solutions of antimony golden yellow (orange) antimony sulphide (Sb_2S_3), which, like the sulphides of arsenic, tin, gold, and platinum, will dissolve in ammonium sulphydrate solution. If, into an acid solution of antimony is placed zinc and platinum in the form of plates, an electrolytic action takes place with the deposition of antimony on the platinum as a black spot. This black spot is soluble in a solution of potassium permanganate.

As mentioned under Arsenic, Marsh's tests can be used for the detection of antimony. In fact, the two elements act so similarly when subjected to Marsh's test as to render it difficult to distinguish between them. When antimony is used in Marsh's test, however, the hydrogen flame has a tint which an expert can easily distinguish from arsenic. The spot produced by placing a clean piece of porcelain into the flame (which is none other than separated metallic antimony) is darker than the similar arsenic spot, and possesses less metallic lustre. Moreover, it is insoluble in Labarraque's solution, while the arsenic spot dissolves readily in this reagent.

Fleitmann's test does not respond to antimony, and is, therefore, to be preferred in the detection of arsenic.

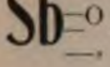
Three oxides of antimony are known, the antimonous oxide, Sb_2O_3, antimonic oxide, Sb_2O_5, and the third oxide, Sb_2O_4.

Sb_2O_4 can be considered as Sb_2O_3 plus Sb_2O_5, which would give us Sb_4O_8 or $2Sb_2O_4$. Besides, it can be regarded as antimonyl antimonate $(SbO)SbO_3$, to understand which the acid forms of antimony must be explained.

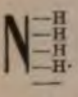
Already we have seen that nitrogen with valences III and V give two oxides, N_2O_3 (nitrous) and N_2O_5 (nitric). Just so are the oxides of antimony, Sb_2O_3 and Sb_2O_5.

The nitrogen oxides, as shown on p. 354, yield, when added to water, nitrous and nitric acids respectively.

Exactly so Sb_2O_3 yields antimonous acid ($HSbO_2$) and Sb_2O_5 gives antimonic acid ($HSbO_3$). Antimonic acid will give salts, such as potassium antimonate ($KSbO_3$), and in Sb_2O_4 we have antimonyl antimonate—$(SbO)SbO_3$, antimonyl being a radicle of valence I $(SbO)^{I}$, graphically



$\mathrm{Sb}\begin{smallmatrix}=\mathrm{O}\\ -\end{smallmatrix}$ just as ammonium is a radicle with valence I $(NH_4)^{I}$, graphically



$\mathrm{N}\begin{smallmatrix}-\mathrm{H}\\ -\mathrm{H}\\ -\mathrm{H}\\ -\mathrm{H}\\ -\end{smallmatrix}$.

The "antimonyl," just spoken of, is found in one of the official preparations—tartar emetic.

The only preparations of antimony recognized in the present pharmacopœia are:

Antimony and potassium tartrate. At least 99.5 per cent. absolute $2K(SbO)C_4H_4O_6 + H_2O$.

Compound syrup of squill, containing 0.2 per cent. antimony and potassium tartrate. Compound mixture of glycyrrhiza, containing 240 milligrammes antimony and potassium tartrate to the liter.

ANTIMONII ET POTASSII TARTRAS—Antimony and Potassium Tartrate

(**Antim. et Pot. Tart.**—Antimonyl Potassium Tartrate. Tartrated Antimony. Tartar Emetic)

It contains not less than 98.5 per cent. of $K(SbO)C_4H_4O_6 + \frac{1}{2}H_2O$ (332.34). Preserve it in well-closed containers.

Summarized Description.

Colorless, rhombic crystals or white, granular powder; sweet, afterward disagreeable metallic taste; soluble in about 12 parts of water; insoluble in alcohol. For details see U.S.P., p. 50.

For *tests for identity*, for *impurities* (iron, arsenic) and for *assay* see U.S.P., p. 50 and also Part V of this book.

This official, commonly called *tartar emetic*, is, in truth, antimonyl and potassium tartrate, since the radicle $(SbO)^I$ enters the compound rather than the element itself. Tartaric acid has the power of easily forming double salts. (See p. 363.) Rochelle salt was one of these double salts, and "tartar emetic" differs from Rochelle salt only in the substitution of antimonyl (SbO) for sodium:

$KNaC_4H_4O_6$ (Rochelle salt). $K(SbO)C_4H_4O_6$ (tartar emetic).

It is made by boiling the antimony oxide with potassium bitartrate and water for an hour. When so treated, the hydrogen of the potassium bitartrate is eventually replaced by the antimonyl group furnished by the antimony oxide.

Antimony and potassium tartrate, as its synonym would indicate, is used as an emetic, in large doses, while in small doses it acts as an alterative and diaphoretic and expectorant. It was formerly largely used as an emetic, but its action was so violent that it has largely fallen into disuse. If given in an overdose, the antidote is tannin.

Dose.—Expectorant, 5 milligrammes ($\frac{1}{12}$ grain).

Tartar emetic is a constituent of two official galenics, *compound syrup of squill* (p. 200) and *compound mixture of glycyrrhiza* (p. 257).

Antimonii Oxidum (U.S.P. 1890; N.F. IV) or *antimony oxide*, shows antimony with the valence III, it being the "ous" oxide, Sb_2O_3. It was the main ingredient of the *antimonial powder* (U.S.P. 1890).

The manufacture of this compound is rather intricate. Antimony sulphide is first dissolved in hydrochloric acid, whereby soluble antimony chloride, *butter of antimony*, is produced:

$$Sb_2S_3 + 6HCl = 2SbCl_3 + 3H_2S.$$

The filtered solution is then poured into a large quantity of water, with the production of an insoluble oxychloride, shown by the following equation:

$$12SbCl_3 + 15H_2O = 2SbCl_3 5Sb_2O_3 + 30HCl.$$

This insoluble oxychloride (*powder of algaroth*) is then treated with ammonia water, which converts it into the pure oxide, as is shown in the following equation:

$$2SbCl_3 5Sb_2O_3 + 6NH_4OH = 6Sb_2O_3 + 6NH_4Cl + 3H_2O.$$

This oxide is washed to free it from ammonium chloride and then dried.

The product is a white powder, insoluble in water and is used as an alterative in 1-grain doses.

Antimonial powder (U.S.P. 1890: N.F. IV) or *James' powder* is a galenic made by triturating 33 Gm. of the oxide with 67 Gm. of calcium phosphate. (See p. 294.)

Antimony sulphide was official in three forms in the pharmacopœia of 1890.

First: The crude ore containing arsenic, despite the efforts to remove it by fusion.

Second: The purified, from which the arsenous sulphide has been removed by water of ammonia.

Third: Sulphurated, which is made by a process similar to that followed in making precipitated sulphur. (See p. 380.) Although the chemical reaction is quite different in both cases, the substance which we desire to purify, and which is insoluble, is dissolved by boiling with alkali (lime in the case of precipitated sulphur, soda in sulphurated antimony), and the product desired precipitated with acid; "*Kermes mineral*" (as the sulphurated antimony is called), is not a pure sulphide, Sb_2S_3, but is a mixture of this with Sb_2O_3. It is called Kermes mineral, from a supposed resemblance to Kermes, an ancient dye-stuff.

Antimonii Sulphidum (U.S.P. 1890) or *antimony sulphide* is too crude for internal use, containing, as it does, a large quantity of arsenic. It is used very largely in veterinary practice as an alterative under the name of *black antimony*, and should never be dispensed for human consumption.

Antimonii Sulphidum Purificatum (U.S.P. 1890) represented crude antimony sulphide, purified by washing with ammonia, the theory of this washing being that arsenic sulphide is soluble in ammonia water. However, antimony sulphide itself is somewhat soluble in ammonia water, and therefore the process is wasteful. Equally good results would be obtained, as far as freeing the sulphide from arsenic is concerned, by washing with a mixture of ammonia water and ammonium carbonate, in which solvent an antimony sulphide is scarcely soluble.

The purified sulphide of antimony is used as an alterative in doses of 1 grain.

Antimonii Sulphuratum (U.S.P. 1890; N.F. IV), or *Kermes mineral*, is made by boiling antimony sulphide with soda and precipitating the alkaline solution with sulphuric acid.

The equations occurring in this process are as follows:

$$\begin{array}{llllllllll}
(a) & Sb_2S_3 & + & 6NaOH & = & Na_3SbO_3 & + & Na_3SbS_3 & + & 3H_2O. \\
(b) & 2Na_3SbO_3 & + & 3H_2SO_4 & = & 3Na_2SO_4 & + & Sb_2O_3 & + & 3H_2O. \\
(c) & 2Na_3SbS_3 & + & 3H_2SO_4 & = & 3Na_2SO_4 & + & Sb_2S_3 & + & 3H_2S.
\end{array}$$

Sulphurated antimony is an alterative and diaphoretic. It is much esteemed by French physicians, who find it a valuable constituent for cough-mixtures, a favorite recipe for this purpose being 1 grain of sulphurated antimony in 1 ounce of syrup of wild cherry, a teaspoonful being given as a dose. Its dose is usually from ½ to 1 grain.

Compound pills of antimony (N.F. IV) or *Plummer's pills*, consist of sulphurated antimony, powdered guaiac, and calomel. They are used in secondary syphilis, one or two pills being the dose.

Another unofficial antimony compound worth passing mention is *pyroantimonic acid*, $H_4Sb_2O_7$. This compound, as it will be seen, has the formula analogous to that of pyrophosphoric acid, already discussed on p. 441, its potassium salts being used for the detection of sodium, sodium pyroantimoniate being practically the only insoluble sodium compound.

TIN

Symbol, Sn. Atomic weight, approximately 118

While this element yields no official compounds, it is of sufficient importance to justify passing notice.

The source of tin is the oxide, SnO_2, which is commonly called *tin stone*, and mined very largely in Cornwall, England, Malacca, and Dakota.

Tin has been used for many centuries, Pliny's *kassiteros* (or plumbum candidum), which he says came from the Cassiterides in the Atlantic, being our modern Britain. The Latin word *stannum* is derived from the Saxon *stan*, meaning stone.

The metallurgy of tin, like that of so many other metals, is accomplished by heating together coal and the oxide, freed from sulphur and arsenic by roasting, the reaction being as follows:

$$SnO_2 + C_2 = Sn + CO_2.$$

Tin is a brilliant white metal, very malleable, and thus can be made out into very thin sheets, which are much used by pharmacists under the name of *tin-foil*. The so-called *tin-plate* consists of sheets of iron coated with tin, either by dipping the iron into the molten metal or by rolling the tin upon the iron plate.

Tin compounds are tested as follows: Potassium hydroxide produces a white precipitate of tin hydroxide; ammonium sulphide produces a black precipitate when a stannous salt is under treatment (stannous sulphide); a yellow precipitate of stannic sulphide, if the tin compound is of the higher valence. The special test for stannous tin is the fact that if a solution of mercuric chloride is mixed with a solution of stannous salt, the mercuric salt is reduced to metallic mercury, with a corresponding separation of the metal as a gray precipitate.

Two oxides of tin are known, stannous oxide, SnO, and the stannic oxide, SnO_2. In these, like in the other tin compounds, the stannous form of tin exhibits the valence II, while the stannic form shows valence IV.

No compounds of tin are official. The following, however, are of passing interest in pharmaceutic chemistry. *Stannous chloride*, $SnCl_2$, is made by treating the metal with hydrochloric acid, and is used in analytic work as a reducing agent, as shown in the mercury test for stannous compounds that has just been given.

Stannic chloride, $SnCl_4$, was first made by Libavius (1605) by distilling tin with mercuric chloride. When water-free, it is a colorless, fuming liquid, which was formerly known as *spiritus fumans Libavii.*

Tin, like zinc and aluminum, stands midway between the positive and negative elements, and while generally acting as a metal in its compounds, it forms, with alkalies, salts of stannic acid, H_2SnO_3. The sodium salt, Na_2SnO_3, is used largely in calico printing under the name of "*tin salt.*"

GOLD

Symbol, Au. Atomic weight, approximately 196

Gold is usually found in the native, uncombined form, being associated with either sand or quartz. It is beyond the limits of this work to go into extended consideration of the production of gold, and therefore suffice it to say that it is found in certain sections of the world, such as, for instance, California, Alaska, Australia, and South Africa.

The mining of gold is accomplished in several ways, according to the condition in which the metal is found. When found associated with sand, it is usually extracted from the beds of rivers. In this case the gold is separated from the sand by the process of washing, which can be compared to levigation. (See p. 117.) If done on a small scale, the mixture is placed in a pan, and washed rapidly with water, whereby the sand is washed out, leaving the heavier gold in the bottom of the pan. The washing is performed on a large scale by the process of "placer-washing," which consists of putting the gold-bearing sand into the upper one of a series of long troughs, each trough being slightly lower than its predecessor.

Into the top trough is run a good stream of water (usually from an adjacent mountain torrent), which, passing continuously through, gradually throws out all the sand, and, at the same time, a large quantity of the gold. The mixture of sand and gold passes to a second trough, where a considerable quantity of the gold separates out, while all the sand is washed out into the third trough. And thus the process goes on until all the sand has been removed, while practically all the gold remains in the troughs.

The crude gold is purified by the amalgamation process—that is, it is treated with mercury—and the amalgam then submitted to distillation, when the mercury passes over, leaving the gold in the still.

When gold is found in quartz, the gold is extracted by either of two methods.

In the chlorine process the ore is roasted to remove sulphur and arsenic residue mixed with water and treated with chlorine. Gold is separated from the resulting gold chloride solution by precipitation with ferrous sulphate.

In the *cyanide process* the finely ground ore is percolated with a dilute solution of potassium cyanide, which dissolves the gold as a double cyanide. The metal is separated from the percolate by electrolysis.

Gold is one of the most ancient of metals, ornaments of the metal being found in the Egyptian tombs. The Latin word for gold, *aurum*, is of classic origin, being derived from the Hebrew word *zohov*, which meant the color of fire. It is of interest to note that in many of the ancient languages the word distinguishing gold is the same word used to signify yellow.

Gold is a soft yellow metal, having the specific gravity 19.00. It is the most malleable of all metals, capable of being beaten into sheets (leaves) so thin that 280,000 of them are required to measure an inch. When beaten out so thinly, the sheets are translucent, and the light transmitted through them is of a greenish color. Gold is also a very ductile metal, although it is not capable of being drawn into wire as thin as is platinum. It is not soluble in nitric acid nor in hydrochloric acid, but it does dissolve in a mixture of the two—aqua regia (see p. 396), which is supposed to act on the metal, not by reason of the composition of either of the constituents, but because of the free chlorine and nitrosylchloride contained in the nitrohydrochloric acid. Because of the softness of the pure metal, gold is always employed in the form of an alloy.

The gold coins of America consist of 90 per cent. of gold and 10 per cent. of copper, while the gold used in making jewelry contains a still larger quantity of copper. The rating of the gold content of jewelry gold is not by percentage, but by a clumsy commercial standard called *karats.* Pure gold is said to be 24 karats. Hence when we speak of 14-karat gold we mean that it is $^{14}/_{24}$ gold.

The *tests* for gold are as follows: Hydrogen sulphide gives the black precipitate of gold sulphide. When a fresh solution of ferrous sulphate is added to a solution of gold salt, gold separates out, and when gold salts are treated with tin chloride in the presence of a ferric salt, a beautiful purple precipitate is formed. This precipitate, which is either $SnAu_2(SnO_3)_2$, or a solution of colloidal gold containing a trace of stannic compounds, was formerly used as a pigment under the name of *purple of Cassius.*

Gold usually exhibits the valence III, although monovalent gold is known in such compounds as $AuCl$ and Au_2O.

The only official salt of gold is—

AURI ET SODII CHLORIDUM—Gold and Sodium Chloride

(Aur. et Sod. Chlor.)

A mixture of equal parts of anhydrous gold chloride [$AuCl_3$ = 303.58] and anhydrous sodium chloride [$NaCl$ = 58.46], representing, when dried to constant weight in a desiccator over sulphuric acid, not less than 30 per cent. of metallic gold [Au]. Preserve it in well-stoppered, amber-colored vials.

Summarized Description.

Orange-yellow, deliquescent powder; saline, metallic taste; very soluble in water; partly soluble (the gold chloride) in alcohol and ether. For details see U.S.P., p. 70.

For *tests for identity,* for *impurities* (free hydrochloric acid, metallic impurities) and for *assay* see U.S.P., p. 70 and also Part V of this book.

Remarks.—Gold chloride is very deliquescent, and to lessen this disagreeable quality as much as possible the pharmacopœia directs it combined with an equal weight of "decrepitated" sodium chloride. Decrepitated salt means that from which the interstitial water has been driven by heat. Salt, when heated, crackles, because the interstitial water forms steam which explodes with sufficient force to break the crystals.

The mixture of dried gold chloride with anhydrous common salt is official as *gold and sodium chloride.*

The gold chloride is made by dissolving gold in aqua regia. The filtered solution is then evaporated, when there crystallizes chlorauric acid, $HAuCl_44H_2O$.

If this be mixed with sodium chloride, true gold and sodium chloride, $AuCl_3NaCl2H_2O$, results. This is not the official body, which, as above stated, is made by triturating dried gold chloride with an equal quantity of dried salt.

Gold chloride is best made by treating gold with chlorine, since the product obtained by evaporation of an aqua regia solution is apt to contain aurous chloride, AuCl.

Gold and sodium chloride is used as an alterative. Of late, gold chloride and other compounds have been much vaunted as remedies for the drink habit. That the so-called gold cure is efficient cannot be denied, but whether due to the gold or to the other stimulants employed is a matter still open for discussion.

Dose.—5 milligrammes ($\frac{1}{12}$ grain).

Acidum Bromauricum (N.F.) or *bromauric acid*, $HAuBr_4 + 5H_2O$, is a definite compound of gold bromide and hydrobromic acid. It contains 32 per cent. metallic gold. It is used as an alterative in $\frac{1}{10}$-grain doses.

Liquor Auri et Arseni Bromidi (N.F.) is made by preparing arsenic bromide, (heating together arsenic trioxide, bromine and water) and then adding to the pure bromide solution, bromauric acid. It represents one-fourth of 1 per cent. of As_2O_3 about one-third of 1 per cent. of bromauric acid.

PLATINUM

Symbol, Pt. Atomic weight, 193.3

Platinum occurs native, and is found in Mexico, Brazil, and chiefly in the Ural Mountains. The metal thus obtained is always contaminated with palladium, iridium, osmium, ruthenium, and the separation of these precious metals is a matter of considerable difficulty.

Platinum was first brought to the attention of the world by de Ulloa, in 1746, who, in his descriptions of his explorations of Mexico, referred to the metal there discovered. The word *platina* (little silver) was first applied to the metal by Scheffer in 1752.

Platinum is the most ductile of all metals, it having been drawn into wire so thin that a microscope is required to see the strand. It is one of the most difficult of the metals to be fused, and for this reason it is of great value in the making of crucibles or similar vessels to be used for high heat. (See p. 82.) It must be noted, however, that platinum utensils are by no means unaffected by any substance, experience having shown that the metal forms a fusible alloy with lead and a fusible phosphide with phosphorus; that also alkaline hydrates, sulphides, hypophosphites, and cyanides attack the platinum, eventually eating through the same; so none of these substances should be heated in platinum dishes.

Spongy platinum is an interesting form of the metal. It is made by heating platino-ammonium chloride (see below) until all the ammonia and chlorine have been driven off, leaving a spongy lump of platinum which possesses remarkable absorptive capacity for oxygen, it being stated that one volume will absorb 250 volumes of that gas. The oxygen thus absorbed is in a condition readily to combine with other substances, notably hydrogen, and this principle was made use of in the so-called Doebereiner's lamp, which was largely used before the introduction of matches. This lamp consists of an ordinary hydrogen generator, with a piece of spongy platinum placed near the nozzle, from which the hydrogen gas would be emitted. As soon as a stream of hydrogen is placed on the spongy platinum, a chemical union between oxygen (from the air) and hydrogen takes place, with a heat sufficiently intense to cause the ignition of the hydrogen, and thus producing flame.

Another interesting point connected with platinum is the fact that at red heat a sheet of platinum permits hydrogen to pass through it, no other gas being thus given transit. This phenomenon has been made use of for the removal of hydrogen from a mixture of gases.

The *tests* for platinum are as follows: Hydrogen sulphide produces a brown sulphide, and potassium chloride added to a solution of platinic chloride will produce the characteristic yellow crystals. These crystals have already been discussed under

Potassium. A similar precipitate of platinic ammonium chloride is produced when ammonium chloride is also treated with platinic chloride.

No salts of platinum are official, but *platinic chloride*, $PtCl_4$, is mentioned in the appendix to the pharmacopœia as a constituent of the test solution used for testing for the presence of potassium.

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CHAPTER XXXIII

CADMIUM, COPPER, AND BISMUTH

CADMIUM

Symbol, Cd. Atomic weight, 111.6

CADMIUM is a mineral which is usually found in combination with zinc; most calamines containing cadmium. The most important cadmium mineral is *greenockite*, which is chiefly cadmium sulphide.

The name is derived from the Greek word *kademia*, which was the ancient name for calamine. The element was isolated from this ore by Strohmeier in 1817.

Cadmium is a white metal, like tin, and like it crackles when bent; it has a higher specific gravity, however, and is more tenacious.

The *tests* for cadmium are the yellow sulphide, produced by treating solutions of the salts with hydrogen sulphide or with ammonium sulphide, and the white hydroxide, precipitated when the solution of the salt is treated with potassium hydroxide or ammonium hydroxide. This hydroxide is insoluble in an excess of potassa, but soluble in an excess of ammonia. Sodium carbonate precipitates cadmium salts in the form of white cadmium carbonate, which is insoluble in an excess of the reagent.

Cadmium usually exhibits the valence II, as shown in the oxide, CdO. No salts of cadmium are official.

COPPER

Symbol, Cu. Atomic weight, approximately 63

This important metal is found in nature as metallic copper; also is found in the ore *copper glance*, Cu_2S; also as cuprous oxide, while native copper carbonate forms a beautiful green mineral, *malachite*.

Copper has been known from the most ancient times, its name, cuprum, coming from *cyprum*, the isle of Cyprus, where the ores were first mined. The metallurgy of the copper ores depends upon the character of the ore. If the ore is chiefly copper oxide, the separation is easily effected by heating ore with carbon, as expressed in the following equation:

$$Cu_2O + C = Cu_2 + CO.$$

Sulphides, on the other hand, are first roasted with sand and some substance which will act as a flux. This action partially converts the ore into copper oxide. By heating this mixture, sulphur dioxide is liberated and copper remains, as expressed by the following equation:

$$CuS + 2CuO = 3Cu + SO_2.$$

Chemically pure copper is prepared by the electrolysis of copper sulphate.

Copper is a brilliant red metal, ductile and malleable. When chemically pure, it is an admirable conductor of electricity, and its use for this purpose is so extensive that the supply is scarcely equal to the demand. The metal is insoluble in either diluted hydrochloric acid or diluted sulphuric acid, except in presence of air, but it does dissolve in concentrated sulphuric acid with the formation of copper sulphate.

An important use of copper is in the formation of the well-known series of alloys. Thus *brass* is made by the fusion of three parts of copper and one part of zinc. *Bronze* represents the mixture of copper, tin, zinc, and lead. *Japanese bronze* contains gold and silver, in addition to the metals above given. *Phosphor-bronze* consists of 90 per cent. of copper, 9 per cent. of tin, and 1 per cent. of phosphorus. This is a remarkably tough and durable alloy, and is, therefore, of great value in making metallic bearings. Copper coins usually consist of 95 per cent. of copper, 4 per cent. of tin, and 1 per cent. of zinc.

The *tests* for copper are: The black sulphide produced by treatment with hydrogen sulphide or ammonium sulphide; the brown-red copper ferrocyanide formed when a solution of a copper salt is treated with potassium ferrocyanide, and the green color a copper salt transmits to a colorless flame. More characteristic, however, is the reaction of copper salts with ammonia. When such solutions are treated with concentrated ammonia water, the blue cupric oxide is precipitated. If, on the other hand, a copper sulphate is treated with diluted ammonia, the blue precipitate redissolves, with the formation of azure-blue solution. This solution contains ammoniated copper sulphate, having the following formula,

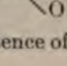
$$Cu\left\langle\begin{matrix}NH_3\\NH_3\end{matrix}\right\rangle SO_4,$$

and is quite characteristic. It must be borne in mind, however, that nickel salts, when treated with ammonia, give a similar azure-blue solution. If metallic zinc or iron is brought in contact with a copper salt, an electrolytic action sets in, with the deposition of metallic copper on the other metal. This can be demonstrated by dipping into a copper solution a steel spatula, which, on removal, will be found plated with copper. As mentioned on p. 272, this test is a simple way for detecting the presence of copper in vegetable extracts.

Three oxides of copper are known—Cu_2O, CuO, and CuO_2.

Cu_2O (cuprous oxide) is a brick-red precipitate obtained by treating copper sulphate with an alkali in the presence of a reducing agent. It is best demonstrated in testing substances containing glucose (example, diabetic urine) with Fehling's solution. (See p. 918.)

Cupric oxide, CuO, occurs in the form of black granules or powder; while copper superoxide, CuO_2, graphically,



is a yellowish-brown powder. The existence of Rose's suboxide, Cu_4O, is now seriously doubted.

But one salt of copper is official—

CUPRI SULPHAS—Copper Sulphate

(**Cupr. Sulph.**—Cupric Sulphate)

It contains not less than 62.97 per cent. nor more than 66.79 per cent. of anhydrous copper sulphate corresponding to not less than 98.5 per cent. of the crystallized salt [$CuSO_4 + 5H_2O = 249.72$]. Preserve it in well-closed containers.

Summarized Description.

Deep blue triclinic, efflorescent crystals or blue, granular powder; nauseous, metallic taste, soluble in about 2.5 parts of water, in about 400 parts of alcohol and in about 3.1 parts of glycerin; on heating, first exsiccates and finally dissociates into oxygen, sulphur dioxide and cupric oxide. For details see U.S.P., p. 128.

For *tests for identity*, for *impurities* (other metals) and for *assay* see U.S.P., p. 128 and also Part V of this book.

Remarks.—This substance is known as *blue vitriol*, as already mentioned on p. 398. It is made by treating copper with sulphuric acid. and according as the acid is diluted or concentrated the reaction differs. When copper is treated with diluted sulphuric acid, the equation runs as follows:

$$Cu + H_2SO_4 + \underset{\left(\substack{\text{From} \\ \text{air}}\right)}{O} = CuSO_4 + H_2O.$$

while if the metal is treated with hot concentrated sulphuric acid, the equation is as given below:

$$Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O.$$

It is interesting to note that in neither case is hydrogen produced, as usually occurs when a metal is treated with sulphuric acid.

Large amounts of crude blue-stone are made by roasting various ores and treating the residue with sulphuric acid.

Of the tests given above, its efflorescence and exsiccation are matter of interest; the fifth molecule of water of crystallization, held until the salt is heated to 200°C., being an illustration of water of constitution (p. 150).

Copper sulphate, when given in small doses, acts as an astringent or tonic. If given in large doses, it acts as an emetic, and was formerly considerably used for this purpose. Its action, however, is too irritating to recommend its use in these days. Applied externally in the form of a moistened crystal it is caustic, while a dilute solution is used as an astringent injection in gonorrhea.

Dose.—Emetic, 250 milligrammes (4 grains).

Cupric acetate, which was recognized in the pharmacopœia of 1880, is called *verdigris*, and was formerly in considerable use as an application for ring-worms and other skin troubles.

BISMUTH

Symbol, Bi. Atomic weight, approximately 207

Bismuth is found in nature; it also occurs as sulphide in the ore, *bismuth glance*. The word bismuth is derived from the German *Wismuth*, the origin of this term being supposedly from the two German words *Weise matte*, beautiful meadow. This, however, has been pronounced by Huseman to be merely a pleasant fable, his researches proving that the first mention of the metal in the Bergbuchlein of 1518 was under the name of *Wyssmut*.

The extraction of the metal from the sulphide is accomplished by roasting in a reverberatory furnace, thus forming bismuth oxide, as shown in the following equation:

$$Bi_2S_3 + O_9 = Bi_2O_3 + 3SO_2.$$

On heating bismuth oxide with coal, carbon dioxide is liberated, and metallic bismuth remains,

$$2Bi_2O_3 + C_3 = Bi_2 + 3CO_2.$$

Bismuth is a crystalline, brittle, pulverizable, brilliant metal of silvery color, with, however, a slight reddish tint. In many of its qualities it resembles antimony.

The chief use of the metal is for the formation of fusible alloys, it possessing the characteristic property of blending with certain metals to form an alloy, melting at a temperature much below the melting-point of any of the metals when heated alone. Thus, two parts of bismuth, one part of lead, and one part of tin, the melting-point of the metals being respectively 270°C., 330°C., and 235°C., melts at 94°C. (Rose's fusible metal), while Wood's metal, consisting of four parts of bismuth, one part of cadmium, one part of tin, and two parts of lead, melts at 60.5°C. The chief use of such fusible metals is for automatic fire-sprinklers, these consisting of water-pipes passing along the ceiling of a room, punctured with holes which are plugged with the fusible metal. If a fire breaks out in the apartment, as soon as the temperature reaches 65°, the metallic plugs melt and streams of water are thrown into the room. Pieces of these metals are also used as safety fuses in electric wiring.

Tests.—Bismuth, like so many metals of this group, gives a black sulphide when treated with hydrogen sulphide or ammonium sulphide. A more characteristic test is the fact that acid solutions of bismuth salts, when poured into water, produce a white precipitate of a "sub"-salt. Thus, bismuth nitrate solution, when poured into water, forms bismuth subnitrate, which precipitates out in the form of a white powder.

Three oxides of bismuth are known:

BiO or (Bi_2O_2), which is a black substance, B_2O_3, bismuthous oxide, a yellow powder; and Bi_2O_5, which is red in color.

The bismuthous oxide is the one ordinarily found.

The following compounds of bismuth are official:

Bismuth and ammonium citrate ($BiC_6H_5O_7$) should yield 46 to 52 per cent. absolute bismuth oxide.

Bismuth subcarbonate—approximately $(BiO)_2CO_3$—should yield at least 90 per cent. absolute bismuth oxide.

Bismuth subgallate—approximately $BiC_7H_7O_7$—should yield at least 52 to 57 per cent. absolute bismuth oxide.

Bismuth subnitrate—approximately $BiONO_3$—should yield at least 79 per cent. absolute bismuth oxide.

Bismuth subsalicylate—approximately $Bi_2O_3(C_7H_5O_3)_3$—should yield at least 62 to 66 per cent. absolute bismuth oxide.

Bismuth betanaphthol, will be considered among the derivatives of betanaphthol.

Bismuth magma should yield from 5.6 to 6.2 per cent. absolute bismuth oxide.

Bismuth Hydroxide, $Bi(OH)_3$, is produced when an acid solution of bismuth nitrate is treated with a soluble hydroxide, preferably a diluted ammonia water. The magma thus produced, when mixed with water has been popular under such names as *bismuth cream* or *bismuth milk*. Such a preparation is now official a:

MAGMA BISMUTHI—Bismuth Magma

(Magma Bism.—Milk of Bismuth)

Bismuth Magma yields not less than 5.6 per cent. nor more than 6.2 per cent. of Bi_2O_3.

Condensed Recipe.

Dissolve 80 Gm. bismuth subnitrate in a mixture of equal volumes of nitric acid and water and mix this with a diluted nitric acid. Dilute 480 mils of ammonia water with water, dissolve therein 10 Gm. ammonium carbonate, and pour into this ammoniacal solution the bismuth solution, after which ammonia water is added if the mixture is not distinctly alkaline. Let the precipitate subside, wash it several times by decantation (or by use of a siphon) with distilled water, transfer to a strainer and wash precipitate until washings are free from alkali. Then drain magma and add enough water to make 1 liter. For details see U.S.P.

Summarized Description.

Thick, white, liquid mixture; neutral to litmus and to phenolphthalein. For *tests for identity* and for *assay* see U.S.P., p. 260.

Dose.—4 mils (1 fluidrachm).

BISMUTHI SUBNITRAS—Bismuth Subnitrate

(Bism. Subnit.)

A basic bismuth nitrate of varying chemical composition, which, when dried for twenty-four hours in a desiccator over sulphuric acid, yields, upon ignition, not less than 79 per cent. of bismuth oxide [Bi_2O_3].

Summarized Description.

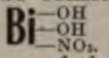
White, slightly hygroscopic powder; insoluble in water and in alcohol; soluble in hydrochloric and nitric acids, acid solution precipitates on addition of water; dissociates at red heat into nitrogen oxides and a yellow residue, that is blackened by hydrogen sulphide. For details see U.S.P., p. 82.

For *tests for identity*, for *impurities* (alkalies and alkaline earths, insoluble foreign salts, chloride, lead, copper, sulphate, silver, arsenic) and for *assay* see U.S.P., p. 83 and also Part V of this book.

Remarks.—An ancient synonym for this preparation was *magisterium bismuthi*, or the master of bismuth, it being considered even in the days of the alchemists as the most important preparation of that metal. The present pharmacopœia gives no symbolic formula for bismuth subnitrate, as its composition varies. In the pharmacopœia of 1880 it was said to be $BiONO_3H_2O$. The formula $BiONO_3$ can be resolved into a combination of Bi_2O_3 and bismuth nitrate,

$$Bi(NO_3)_3,\ \text{viz.,}\ \begin{array}{l} Bi_2O_3 \\ Bi\quad (NO_3)_3 \\ \hline Bi_3O_3(NO_3)_3, \text{ or } 3BiONO_3. \end{array}$$

The formula $BiONO_3H_2O$ can also be considered as a combination of the hydroxide and the nitrate, viz.,



$$Bi\begin{array}{l}-OH \\ -OH \\ -NO_3.\end{array}$$

It is, therefore, apparent that the bismuth subnitrate is a mixture of the oxide and nitrate, even as ferric subsulphate is a combination of iron sulphate and iron oxide.

The bismuth subnitrate is prepared from bismuth nitrate, made by treatment of the metal with nitric acid, as is shown in the following equation:

$$Bi_2 + 8HNO_3 = 2Bi(NO_3)_3 + 4H_2O + N_2O_2.$$

This bismuth nitrate solution invariably contains arsenic, nearly all bismuth ores being contaminated with that metal, and in order to remove the arsenic, an elaborate process is necessary. The solution of nitrate is poured into sodium carbonate solution, when we obtain insoluble bismuth subcarbonate, while the arsenic present goes into solution in the form of sodium arsenate. The precipitate of bismuth subcarbonate is removed from the liquid by filtration, and then dissolved in nitric acid, when the nitrate is again formed. This is treated with a small quantity of water and allowed to stand twenty-four hours, when the remaining arsenic separates out in the form of crystalline bismuth subarsenate. The filtered bismuth nitrate solution is diluted with an equal quantity of distilled water, and to the mixture water of ammonia is slowly added with constant stirring. The pure bismuth subnitrate separates out, and the precipitate is collected on the filter, washed, and dried. In the final separation of the subnitrate the real action is due to the combination of bismuth nitrate with water, as is shown by the following equation:

$$2Bi(NO_3)_2 + 4H_2O = 2BiONO_3H_2O + 4HNO_3.$$

The function of ammonia added is to neutralize the nitric acid separated in the reaction.

At present the salt is made by pouring a solution of chemically pure bismuth nitrate into water.

The pharmacopœia describes bismuth subnitrate as a heavy white powder. A special form of bismuth subnitrate, much esteemed in certain sections of the country, is a French subnitrate which occurs in the form of cones weighing 1.5 grammes, each cone being considered a medium adult dose. These cones are prepared by the process of trochiscation. (See p. 118.)

The percentage of nitric acid combined with the subnitrate is a matter of some importance as it has been found that when above 21 per cent., there is a tendency to hydrolyze when it comes in contact with water. The freed acid is then likely to produce nitrates in the intestines with untoward results. It is claimed that the effervescence of the subnitrate when it comes in contact with bicarbonates or carbonates is due to such hydrolysis.

Bismuth subnitrate is used as an astringent and tonic, although if given in large doses it acts as a sedative, and is somewhat toxic. Its action in diarrhea is largely mechanical, it forming a clammy covering for the inflamed mucous membrane, even as does prepared chalk.

Dose.—500 milligrammes (8 grains).

Bismuthi Citras (U.S.P. VIII), or *bismuth citrate*, $BiC_6H_5O_7$, is made by heating bismuth subnitrate with citric acid and boiling for fifteen minutes, or until the test prescribed by the pharmacopœia shows that all the subnitrate has been converted into citrate. (See Part VII.) This process is an interesting illustration of how a chemical action not usually occurring can sometimes be produced. Ordinarily, the nitric acid combination of bismuth is much stronger than the combination of bismuth with citric acid. But if citric acid is boiled with bismuth subnitrate, it eventually drives off the stronger nitric acid by reason of the fact that the nitric acid is volatile, while the non-volatile citric acid remains in the mixture.

Bismuth subnitrate, as mentioned above, is insoluble in ammonia water, while the bismuth citrate is quite soluble therein, and in the accepted process the boiling is continued until the precipitate is found completely soluble in ammonia water.

Bismuth citrate is an example of a salt made by the union of a trivalent metal (Bi^{III}) with a tribasic acid, $H_3C_6H_5O_7$. One atom of Bi^{III} can replace the three atoms of hydrogen in the citric acid, $H_3C_6H_5O_7$, and thus we get bismuth citrate, $BiC_6H_5O_7$.

Bismuth citrate is a white powder, insoluble in water or alcohol, but soluble in ammonia water with the formation of the soluble bismuth and ammonium citrate. Bismuth citrate is rarely used in medicine, and about the only reason why it was given recognition in U.S.P. VIII was because it is used in the manufacture of bismuth and ammonium citrate.

BISMUTH ET AMMONII CITRAS—Bismuth and Ammonium Citrate

(Bism. et Ammon. Cit.—Bismuth Ammonio-Citrate)

Bismuth citrate rendered soluble by the presence of ammonium citrate, which, when dried to constant weight in a desiccator over sulphuric acid, yields, upon ignition, not less than 46 per cent. nor more than 52 per cent. of bismuth oxide [Bi_2O_3]. Preserve it in well-closed containers protected from light.

Summarized Description.

Shiny, pearly or translucent scales; metallic taste; becomes opaque on exposure to air; very soluble in water; sparingly soluble in alcohol; on heat it fuses, then chars, leaving blackened residue, with a yellow surface. For details see U.S.P., p. 79.

For *tests for identity*, for *impurities* (nitrate, chloride, lead, copper, sulphates, silver, arsenic, alkalies, alkaline earths) and for *assay* see U.S.P., p. 80 and also Part V of this book.

Remarks.—This preparation is made by dissolving bismuth citrate in ammonia water and evaporating the filtered solution on the water-bath to syrupy consistence, and scaling the same by spreading it on plates of glass.

Bismuth and ammonium citrate is in the form of small pearly scales, becoming opaque on exposure to air. It is very soluble in water and but sparingly soluble in alcohol.

In order to secure the bismuth and ammonium citrate in the form of translucent scales it is necessary to spread it very thinly on glass, and it might be worth noting that the scales of bismuth and ammonium citrate are not as handsome as are the iron scale preparations—ferric citrate, for instance. If the solution is spread thickly on glass, white, opaque scales are formed, and, as has already been noted in the official description, often the pearly scales become opaque on exposure to air. A similar statement can also be made in regard to the solution of bismuth and ammonium citrate. This forms a clear, transparent liquid when freshly prepared, but on standing it becomes cloudy, due to gradual loss of ammonia, and, as the ammonia separates, insoluble bismuth citrate precipitates out. This cloudy solution can be cleared by the addition of a few drops of ammonia water.

Bismuth citrate is used as an astringent and tonic. It will be noted that the dose is much smaller than that of bismuth subnitrate. This is due to the fact that the bismuth and ammonium citrate is a soluble product, and it must be borne in mind that when bismuth compounds are soluble, they are by no means harmless. In fact, many therapeutists deprecate the administration of soluble bismuth compounds by reason of their possible toxic action. Bismuth and ammonium citrate was the basis of the *elixir of bismuth* and the *elixir of pepsin and bismuth* of the previous edition of the National Formulary. The recipe for the latter preparation was unsatisfactory, however, because of the incompatibility of bismuth and ammonium citrate combined with pepsin. Bismuth and ammonium citrate is held in solution by alkalies and precipitated by acids and, if we add enough alkali to hold the bismuth citrate in solution, pepsin will be decomposed, while if we add an acid solution of pepsin, bismuth citrate will eventually precipitate.

Dose.—125 milligrammes (2 grains).

Glyceritum Bismuthi (N.F.) is a glycerinic solution of a double tartrate of sodium and bismuth, which is soluble in both acids and alkalies and which therefore can be used with pepsin mixtures. (See p. 846.) Also note that the Formulary gives recipes for *liquor bismuthi* (p. 190), for *elixir bismuthi*, for *elixir pepsini, et bismuthi* and for *elixir pepsini, bismuthi et strychninæ* (pp. 207 and 209).

BISMUTHI SUBCARBONAS—Bismuth Subcarbonate

(Bism. Subcarb.)

A basic bismuth carbonate of varying chemical composition, which, when dried to constant weight at 100°C., yields, upon ignition, not less than 90 per cent. of bismuth oxide [Bi_2O_3].

Summarized Description.

White or pale yellowish-white powder; insoluble in water or in alcohol; soluble in nitric or hydrochloric acids with effervescence; nitric acid solution is made turbid by addition of water; dissociated at red heat into water carbon dioxide and a yellow residue of bismuth oxide. For details see U.S.P., p. 80.

For *tests for identity*, for *impurities* (chlorides, lead, copper, sulphate, silver, nitrate, arsenic, alkalies, alkaline earths) and for *assay* see U.S.P., p. 81 and also Part V of this book.

Remarks.—No formula for bismuth subcarbonate is given in the present pharmacopœia, but the standard of 1880 declared it to be $(BiO)_2CO_3$. This formula may be resolved into bismuth oxide and bismuth carbonate, as is here shown:

Bismuth oxide	$2Bi_2O_3$ or Bi_4O_6
Added to Bismuth carbonate	$Bi_2(CO_3)_3$
Gives	$Bi_6O_6(CO_3)_3$
Or	$3(BiO)_2CO_3$.

Bismuth subcarbonate is prepared by dissolving metallic bismuth in nitric acid, and with careful handling the resulting bismuth nitrate solution is freed from the arsenic by diluting with a little water and allowing the mixture to stand in order to permit the subarsenate to separate out. This is filtered, and to the filtered liquid an equal quantity of water is added, and then a small amount of ammonia water, when the subnitrate precipitates. The bismuth subnitrate is redissolved in nitric acid, the filtered nitrate solution is then poured into a solution of sodium carbonate, and the precipitate of bismuth subcarbonate collected on the filter, washed, and dried.

Bismuth subcarbonate is used as an astringent and tonic, and in use resembles bismuth subnitrate.

Dose.—500 milligrammes (8 grains).

BISMUTHI SUBGALLAS—Bismuth Subgallate

(Bism. Subgal.—Dermatol)

A basic bismuth gallate of varying chemical composition which, when dried to constant weight at 100°C., yields, upon ignition, not less than 52 per cent., nor more than 57 per cent., of bismuth oxide [Bi_2O_3].

Summarized Description.

Amorphous, bright yellow powder; insoluble in water, alcohol or ether and in very dilute mineral acids; soluble with decomposition in hydrochloric, nitric and sulphuric acids; soluble in alkaline hydroxide solutions; chars on heating and then leaves residue of bismuth oxide. For details see U.S.P., p. 81.

For *tests for identity*, for *impurities* (chlorides, lead, copper, sulphate, silver, arsenic, nitrates, free gallic acid, alkalies, alkaline earths) and for *assay* see U.S.P., p. 82 and also Part V of this book.

Remarks.—This official is prepared by treating an acetic acid solution of bismuth nitrate with gallic acid. It is popularly known as *dermatol*, and is used as an astringent, both externally and internally.

Dose.—500 milligrammes (8 grains).

BISMUTHI SUBSALICYLAS—Bismuth Subsalicylate

(Bism. Subsalicyl.)

A basic bismuth salicylate of varying chemical composition, which, when dried to constant weight at 100°C., yields, upon ignition, not less than 62 per cent. nor more than 66 per cent. of bismuth oxide [Bi_2O_3]. Protect it from light.

Summarized Description.

White, or nearly white, amorphous or crystalline powder; almost insoluble in cold water; decomposed on boiling with water; partly soluble, with decomposition in hydrochloric or nitric acid; chars at red heat, finally leaving yellow residue of bismuth oxide. For details see U.S.P., p. 83.

For *tests for identity*, for *impurities* (free salicylic acid, nitrate, chlorides, lead, copper, sulphate, silver, arsenic) and for *assay* see U.S.P., p. 83 and also Part V of this book.

Remarks.—Bismuth subsalicylate is made by triturating and warming an aqueous solution of salicylic acid with anhydrous bismuth oxide, obtained by boiling bismuth hydroxide which has been prepared by precipitating a nitric acid solution of bismuth subnitrate with potassium hydroxide or ammonium hydroxide. It is used as an intestinal antiseptic.

Dose.—500 milligrammes (8 grains).

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CHAPTER XXXIV

LEAD, MERCURY, AND SILVER

LEAD

Symbol, Pt. Atomic weight, 205.35

Lead occurs in the form of sulphide in the ore *galena*. By way of passing it is worth noting that some galena ore contains considerable silver. (See p. 561.) Among the other ores of lead are various forms of the carbonate and the sulphate.

Metallic lead was used in classic times, the Latin name ***plumbum*** being the same applied to it by classic writers, its original meaning being "heavy."

Lead is prepared from the sulphide by roasting in a reverberatory furnace, thus converting the sulphide, under the influence of atmospheric oxygen, into lead oxide and lead sulphate, shown in the following equations:

$$PbS + O_3 = PbO + SO_2.$$
$$PbS + O_4 = PbSO_4.$$

The resulting lead oxide combines with a new portion of lead sulphide with the formation of the metal and the separation of SO_2, by the following equation:

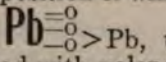
$$2PbO + PbS = Pb_3 + SO_2,$$

while the lead sulphate reacts with more lead sulphide in the manner shown in the following equation:

$$PbSO_4 + PbS = Pb_2 + 2SO_2.$$

Lead is a heavy, bluish metal, freely malleable, and somewhat ductile. Its pliability has given rise to its extended use in plumbing, the name of the craft being derived from the word *plumbum*, lead, since leaden pipes are largely used for the transport of water. It should be said that lead water-pipes are scarcely harmless, traces of lead hydroxide dissolving, and water so contaminated produces a dangerous ailment called lead colic. With hard water, *i.e.*, water containing lime and magnesia dissolved by aid of carbon dioxide, there is less danger, as carbonic acid acts on fresh lead, forming lead carbonate, which coats the interior of the pipe and prevents any of the lead dissolving in the water. Lead is used in the manufacture of *solder*, which is a variety of the fusible metal made by combining equal quantities of tin and lead. This mixture melts at 186°C., and is used for fastening pieces of tin or other metal together.

The *tests* for lead are as follows: Hydrochloric acid produces a white precipitate of lead chloride, being one of the three chlorides thus precipitated, the other two metals precipitated in the form of chloride being silver and mercurous compounds. Lead gives with hydrogen sulphide and ammonium sulphide a black sulphide; with sulphuric acid it precipitates white lead sulphate, and with carbonates, white lead carbonate is precipitated out of the solution. Quite characteristic is the yellow precipitate of lead chromate produced when a solution of lead salt is treated with a solution of potassium chromate.

Five oxides of lead are known, Pb_2O, a black velvety powder, PbO, or *litharge*, U.S.P.; Pb_2O_3, which may be considered as a mixture of PbO and PbO_2, the composition of which can best be explained by the following graphic formula,  $Pb\begin{matrix}=O\\-O\\-O\end{matrix}>Pb$, that is, a combination of lead with valence IV, with lead with valence II; PbO_2, which is called *puce-colored lead oxide*, in which lead shows valence IV; Pb_3O_4, or *red lead* (N.F. IV), which can be considered as a combination of Pb_2O_3 and PbO, or else as a lead plumbate, Pb_2PbO_4; that is, the lead salt of orthoplumbic acid, $Pb(OH)_4$ or H_4PbO_4. Red lead is made by sprinkling hot litharge with water and carefully drying. It is of value as a pigment.

The official preparations of lead are:

Lead acetate. At least 99.5 per cent. absolute $Pb(C_2H_3O_2)_2 + 3H_2O$.

Solution of lead subacetate. Contains lead subacetate, $Pb_2O(CH_3COO)_2$ corresponding to at least 18 per cent. lead.

Diluted solution of lead subacetate contains about 4 per cent. solution of lead subacetate.

Lead oxide. At least 96 per cent. absolute PbO.

Lead plaster. A lead oleopalmitate.

Diachylon ointment contains 50 per cent. lead plaster.

PLUMBI OXIDUM—Lead Oxide

(Plumb. Oxid.—Litharge)

It contains, when freshly ignited, not less than 96 per cent. of PbO (223.10). Preserve it in well-closed containers.

Summarized Description.

Heavy yellowish or reddish-yellow powder or minute scales; absorbs moisture and carbon dioxide from the air; almost insoluble in water; insoluble in alcohol; soluble acetic or diluted nitric acid and in warm alkaline hydroxide solutions; on heating becomes darker and then fuses; heated with charcoal reduces to metallic lead. For details see U.S.P., p. 329.

For *tests for identity*, for *impurities* (carbonate) see U.S.P., p. 329.

Remarks.—This oxide of lead is called *litharge*, a word used since ancient times, and derived from the two Greek words, *lithos*, a stone, and *arguros*, silver. It is so called because the ancients discovered that when the ore, crude litharge, was fused, the pure litharge, freed from the mineral impurities, fused in the form of bright, shiny, silvery scales.

Manufacture.—The chief source of litharge is as a side-product in obtaining silver from galena. The ore (lead sulphide, p. 544) is calcined, thus driving off the sulphur, and the residue brought to a state of fusion, when the lead oxide separates out by crystallization from the fused mass of silver.

Litharge is but little used in medicine, although important as a constituent of two popular pharmaceuticals, solution of lead subacetate and lead plaster.

PLUMBI ACETAS—Lead Acetate

(Plumb. Acet.—Sugar of Lead)

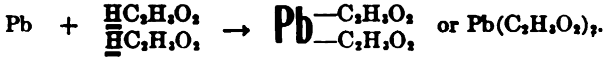
It contains not less than 85.31 per cent. nor more than 89.57 per cent. of anhydrous lead acetate, corresponding to not less than 99.5 per cent. of the crystallized salt [$Pb(C_2H_3O_2)_2 + 3H_2O = 379.20$]. Preserve it in well-closed containers.

Summarized Description.

Colorless, shining, efflorescent, monoclinic prisms or plates, or heavy white crystalline masses or granular crystals; faintly acetous odor; sweetish, astringent, then metallic taste; soluble in about 1.4 parts of water and in about 30 parts of alcohol; quite soluble in glycerin; on heating is exsiccated, then fuses and then dissociates. For details see U.S.P., p. 328.

For *tests for identity*, for *impurities* (carbonate, iron and copper) see U.S.P.

Remarks.—Lead acetate is incorrectly and dangerously called "*sugar of lead.*" Lead being bivalent, it can replace two hydrogen atoms in an acid, and since acetic acid has but one replaceable hydrogen atom to the molecule, two molecules of acetic acid are needed to combine with one atom of lead, thus:



$$Pb + \begin{matrix}\underline{H}C_2H_3O_2\\ \underline{H}C_2H_3O_2\end{matrix} \rightarrow Pb\begin{matrix}-C_2H_3O_2\\ -C_2H_3O_2\end{matrix} \text{ or } Pb(C_2H_3O_2)_2.$$

However, the acetate is usually made by treating the oxide litharge (*not the metal*) with acetic acid.

The solution is concentrated, and the lead acetate is allowed to crystallize. It is important to note that the average commercial lead acetate should not be dispensed without purification, as it contains appreciable quantities of both lead oxide and lead carbonate. The purification of this commercial lead acetate is a simple matter, however, the acetate dissolving in water and recrystallizing, while the impurities do not dissolve.

Lead acetate is used as an astringent and sedative, both internally and externally. An overdose acts as an irritant poison, producing severe gastric disturbances. The antidote for lead-poisoning or in lead-colic is an alkaline sulphate, the one generally preferred being magnesium sulphate or Epsom salt. Externally, it is used either in an aqueous solution or in the form of suppositories, the latter being a highly esteemed remedy for piles, a favorite prescription of this kind being lead acetate with extract of opium and oil of theobroma. The preparation of the suppositories of lead and opium requires considerable skill.

The extract of opium should be rubbed up with enough water to make it into a paste thin enough to pour. The lead acetate should be reduced to the form of an impalpable powder, and added to the molten oil of theobroma, with constant stirring, the mixture is then poured into molds, after adding the thinned extract, just at that moment when the oil of theobroma is ready to solidify. Unless these precautions are followed (especially the stirring), there is danger of the heavy lead acetate settling at the bottom of the dish in which the oil of theobroma is melted, and thus the last suppository poured therefrom will contain a majority of the lead salt. Lead acetate solution is used as a wash for some skin troubles, such as ivy-poisoning and chilblains, but for this purpose a solution of lead subacetate is frequently preferred.

Dose.—60 milligrammes (1 grain).

LIQUOR PLUMBI SUBACETATIS—Solution of Lead Subacetate (Liq. Plumb. Subacet.—Goulard's Extract)

An aqueous solution containing lead subacetate [approximately $Pb_2O(CH_3COO)_2 = 548.25$], corresponding to not less than 18 per cent. of Pb. Preserve the solution in well-stoppered bottles.

Recipe.—See Part. VII.

Summarized Description.

Clear, colorless liquid; sweet, astringent taste; absorbs carbon dioxide from the air; and becomes turbid due to lead carbonate; sp. gr. 1.245. For details see U.S.P., p. 250.

For *tests for identity*, for *impurities* (normal lead acetate) and for *assay* see U.S.P., p. 250 and also Part V of this book.

Remarks.—This preparation—*Goulard's extract*—contains lead subacetate, which, like all "sub-" salts (see Ferric Subsulphate, p. 513), is a combination of a salt of a metal with the oxide of the same metal. Remember it is not a mere mechanical mixture, but a combination like that existing between the sulphates of aluminum and potassium in official alum.

The solution is made by boiling together water, lead acetate, and lead oxide, full details of manufacture and equation, showing chemical action, being given on p. 1003. The pharmacopœia says that the solution contains approximately $Pb_2O(C_2H_3O_2)_2$, which we find corresponds to the sum resulting from the addition of one molecule of lead acetate to one molecule of lead oxide, viz.:

$$\begin{array}{ll} Pb\ (C_2H_3O_2)_2 & \text{(Lead acetate.)} \\ Pb\ O & \text{(Lead oxide.)} \\ \hline Pb_2O(C_2H_3O_2)_2 & \text{(Lead subacetate.)} \end{array}$$

That a chemical change is produced is shown by the fact that the insoluble lead oxide is made to dissolve with the formation of a soluble oxyacetate.

It will be noted that the lead subacetate solution is unstable, especially unless kept tightly corked, the carbon dioxide of the air acting on the solution, with the formation of lead carbonate which precipitates.

Solution of lead subacetate is used almost entirely externally; for this purpose being employed as a sedative and astringent wash in minor skin troubles, such as bruises, frost-bite, and the like. For many purposes of this kind a diluted solution is preferable, and that is provided by the pharmacopœia.

LIQUOR PLUMBI SUBACETATIS DILUTUS—Diluted Solution of Lead Subacetate

Recipe.—See p. 187.

Remarks.—This is made by diluting four parts of the strong solution of lead subacetate, given above, with 96 parts of water, which has previously been boiled in order to expel the carbon dioxide it might contain. (See p. 187.) This solution is usually dispensed in a slightly opalescent condition, first because, on standing, it will gradually become opalescent anyway, and, secondly, to afford a differentiation between the so-called "lead-water" and "lime-water," the latter product being dispensed in a crystal-clear form.

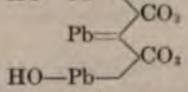
Lead-water is used as a soothing lotion, and is frequently dispensed in combination with a small quantity of tincture of opium. This mixture, while quite popular, is incompatible, for, as soon as the tincture of opium is added to the lead-water, there is formed a flocculent precipitate (lead meconate). The prescription is a usual one, however, and pharmacists always dispense the same, containing the precipitate, placing a "Shake Well!" label on the bottle.

Ceratum Plumbi Subacetatis (U.S.P. VIII; N.F. IV), or *cerate of lead subacetate* made by incorporating solution of lead subacetate with an ointment base consisting of wool-fat, paraffin, white petrolatum, and camphor. It, like the solution from which it is made, was first introduced by the chemist Goulard, hence it is called *Goulard's cerate.*

Goulard's cerate is used for mild skin troubles, and is particularly recommended for cases of chilblain.

Plumbi carbonas (U.S.P. 1890; N.F. IV), or *white lead,* like the carbonates of zinc and of magnesium, is a combination of the carbonate and the hydroxide; the formula given the compound in the pharmacopœia of 1890 having been $(PbCO_3)_2Pb(OH)_2$.

It must be borne in mind that such a formula as the one just given does not represent a mechanical mixture of lead carbonate and lead hydroxide, but a combination far more intimate, which may be best explained by the following graphic formula:



Falk claims that the formula is more complex, that is, $5PbCO_3\ 2Pb(OH)_2PbO$.

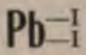
Lead carbonate can be made in small quantities at the prescription counter by combination of molecular quantities of lead nitrate and sodium carbonate, but that used for paint is produced by other means. The oldest method and one still largely used, because of the superiority of the product, as a paint, is that made by the so-called *Dutch process.* By this process sheets of lead are coiled in earthenware pots, moistened with acetic acid. A long series of these pots, carefully covered to prevent the admission of dirt, and yet loose enough to permit the admission of gases, are then placed in rows, are covered with decaying manure or other animal matter, and allowed to stand so covered for five to six weeks. The decaying animal matter produces a large quantity of carbon dioxide, which is gradually absorbed by the lead acetate first produced in the pots by the action of acetic acid on the sheet lead. Experience tells how long the maceration should continue, and when a sufficient length of time has elapsed, the covering of manure is removed, and the contents of the pots are found to consist of powdered white lead. Besides this Dutch process, large quantities of white lead are now made for paints by passing carbon dioxide through a solution of lead subacetate.

Lead carbonate is indicated in some cases of skin trouble and is then usually applied in the form of ointment (unguentum plumbi carbonatis, U.S.P. 1890). This consists of 10 Gm. of lead carbonate in a very finely powdered form, rubbed up with 90 Gm. of benzoinated lard.

A considerable amount of white lead was formerly used as a cosmetic (face powder). Its use for this purpose is dangerous, because of the absorption of the lead through the pores of the skin, which causes lead colic.

Rubbed to a fine paste with linseed oil, white lead constitutes one of the most popular white paints, although such paints should not be used in lavatories or other apartments where there is a possibility of the liberation of hydrogen sulphide gas, which will change the white lead carbonate into the black lead sulphide.

Plumbi Iodidum (U.S.P. VIII; N.F. IV), or *lead iodide,* PbI_2, shows lead with valence, II, the linkage being,



$$Pb\begin{matrix}-I\\-I\end{matrix}$$

This chemical is made by treating a solution of lead nitrate with potassium iodide, as shown in the following equation,

$$Pb(NO_3)_2 + 2KI = PbI_2 + 2KNO_3,$$

and collecting and washing the precipitated lead iodide.

Lead iodide is rarely used internally. When it is, it acts as an alterative, and is given in doses of one to three grains. Its chief value is for external use in tumors and indolent swellings, in which case it is usually employed in the form of the *unguentum plumbi iodidi* (N.F. IV), which is made by rubbing up ten parts of very finely powdered lead iodide with 80 parts of benzoinated lard.

Plumbi Nitras (U.S.P. VIII), or *lead nitrate*, $Pb(NO_3)_2$, is made by treating lead oxide with nitric acid, as shown in the following equation:

$$PbO + 2HNO_3 = Pb(NO_3)_2 + H_2O.$$

The solution of lead is concentrated by the evaporation of the surplus water, and after filtering it is allowed to stand, when the lead nitrate separates in the form of small crystals.

The use of lead nitrate is for the preparation of the other salts of lead. Medicinally, it is used externally as a cooling wash, and enjoys some reputation as a disinfectant.

EMPLASTRUM PLUMBI—Lead Plaster

For recipe, see Part VII.

Remarks.—This is an oleopalmitate of lead prepared by boiling olive oil and lard with a mixture of lead oxide and water. The chemistry of the process will be discussed on p. **1004**. In the last pharmacopœia lead plaster was prepared by precipitating a solution of soap with a solution of lead acetate, but the product was not wholly satisfactory.

As the name indicates, the product is used as a plaster base.

UNGUENTUM DIACHYLON—Diachylon Ointment

(See p. 332.) This ointment consists of melted lead plaster diluted with olive oil and oil of lavender. The ointment was formerly in considerable repute as a remedy for eczema.

MERCURY

Symbol, Hg. Atomic weight, approximately, 200

Mercury occurs chiefly as a sulphide, forming the valuable mineral *cinnabar*, and is occasionally found in the native state. Cinnabar has been known since the time of the Grecian philosophers, and the separation of the metal by heating of cinnabar was described by Dioscorides, while the metal was called hydrargyrum (water silver) by Pliny. It was first used in medicine by Paracelsus.

Metallurgy.—Mercury is obtained by roasting cinnabar in an appropriate retort, when mercury and sulphurous oxide are formed, as shown in the following equation:

$$HgS + \underset{\text{(From air)}}{O_2} = Hg + SO_2.$$

The vapors of sulphurous oxide are permitted to escape, while the metallic mercury is held back in an appropriate condenser.

Mercury is a silvery white, mobile liquid, hence called *quicksilver*. It has a specific gravity of 13.5, and is the heaviest known liquid. It is, moreover, of interest as being the only metallic substance which is liquid at ordinary temperatures. It requires a cold of 40° below zero (both Fahrenheit and Centigrade) to solidify it.

Mercury has the property of combining with almost all the metals (but iron), forming liquid alloys, which we call amalgams; some of which are definite chemical compounds (example, KHg). The fact that iron does not combine with mercury, permits the storage of mercury in iron containers. Mercury boils at 360°C., but vaporizes below that temperature, and the vapor is poisonous. Hence trades demanding the use of a large amount of mercury, such as in making mirrors, are dangerous to the health of the workmen. As mentioned on p. 349, the atomic and molecular weight of mercury is the same, 200.

The *tests* for mercury are as follows: The black sulphide produced by the action of hydrogen sulphide or ammonium sulphide; a routine test, which is of very little value, except in the precipitation of mercury in the regular scheme of analytic chemistry. (See p. 878.) In this test both forms of mercury (the "ous" and "ic") separate in the form of black mercuric sulphide. There are quite a number of characteristic tests differentiating the "ous" compounds from the "ic" compounds. The potassium iodide precipitates from the solution of mercurous salts the yellow mercurous iodide; while the same reagent with the mercuric salts gives a red mercuric iodide. Hydrochloric acid precipitates from solutions of mercurous salts insoluble white mercurous chloride; while with "ic" salts no precipitate is formed by this reagent. Metallic copper or stannous chloride solution, when mixed with a mercurous compound, reduces it to a metallic mercury, which separates out in the form of a fine gray precipitate. Calcium hydroxide solution (lime-water) forms with mercurous compounds a black precipitate of mercurous oxide—Hg_2O—and the liquid so prepared from calomel water and lime-water is called *black wash* (*aqua phagedænica nigra, lotio nigra,* N.F.). Mercuric salts with lime-water form a yellow precipitate of mercuric oxide, and a liquid so prepared from corrosive sublimate water and lime-water is called *yellow wash* (*aqua phagedænica flava, lotio flava,* N.F.).

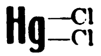
Two oxides of mercury are known—Hg_2O, mercurous oxide, and HgO, mercuric oxide.

Referring to the table of elements on p. 352, we find that mercury is both univalent and bivalent, and we, therefore, have two lines of mercury salts—the mercuric and mercurous.

When speaking of copper on p. 537, attention was called to the fact that that metal exhibited the valence I and II, and that such variation did not agree with the rule, laid down on p. 357, that variation in valence should be by twos. Such exception we found in the ferric and ferrous salts, the apparent valence in that case being II and III, and that exception was explained on p. 503 by the theory that ferric iron really has the valence IV, making iron, II and IV. In a somewhat similar way we explain the valence of copper and mercury. In the mercuric form the valence is undoubtedly II, and mercuric chloride can be expressed as shown in Formula A, given below.

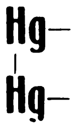
In the mercurous form the valence is also supposed to be II, and all mercurous compounds are supposed to be made up of two atoms of mercury linked as in Formula B. Thus we suppose the formula of mercurous chloride (calomel) is as in Formula C,

FORMULA A



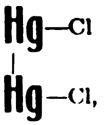
$$\mathrm{Hg}\begin{matrix}-\mathrm{Cl}\\-\mathrm{Cl}\end{matrix}$$

FORMULA B



$$\begin{matrix}\mathrm{Hg}-\\|\\\mathrm{Hg}-\end{matrix}$$

FORMULA C



$$\begin{matrix}\mathrm{Hg}-\mathrm{Cl}\\|\\\mathrm{Hg}-\mathrm{Cl},\end{matrix}$$

and the pharmacopœia of 1890 gave the formula of calomel as Hg_2Cl_2, not $HgCl$, and likewise with all other mercurous salts.

The theory of the bivalency of mercury in mercurous compounds is not, however, unanimously accepted, some chemists considering mercury in the "ous" form as possessing valence I, and thus giving the mercurous bodies the simpler single formula—for example, calomel, $HgCl$. This view is the one recognized in the present pharmacopœia where all formulas (see Alum, p. 492 and Ferric Chloride, p. 503) are given their simplest form.

The official forms of mercury and its compounds are:

Mercury. At least 99.5 per cent. absolute Hg.
Mass of mercury contains from 32 to 34 per cent. mercury.
Mercurial ointment contains 50 per cent. mercury.
Blue ointment contains 30 per cent. mercury.
Mercury with chalk contains from 37 to 39 per cent. mercury.
Ammoniated mercury—$HgNH_2Cl$—contains 78 to 80 per cent. mercury.
Ointment of ammoniated mercury contains 10 per cent. ammoniated mercury.
Corrosive mercuric chloride. At least 99.5 per cent. absolute $HgCl_2$.
Poison tablets of corrosive mercuric chloride. Each tablet contains 0.45 to 0.55 Gm. $HgCl_2$.
Mild mercurous chloride. At least 99.6 per cent. absolute HgCl.
Red mercuric iodide. At least 99 per cent. absolute HgI_2.
Yellow mercurous iodide. At least 99 per cent. absolute HgI.
Red mercuric oxide. At least 99.5 per cent. absolute HgO.
Yellow mercuric oxide. At least 99.5 per cent. absolute HgO.
Ointment of yellow mercuric oxide contains 10 per cent. yellow mercuric oxide.
Oleate of mercury contains 25 per cent. yellow mercuric oxide.
Ointment of mercuric nitrate contains 7 per cent. mercury combined as nitrate.
Mercuric salicylate contains from 54 to 59.5 per cent. of mercury combined as salicylate.

HYDRARGYRUM—Mercury

(Hydrarg.—Quicksilver)

It contains not less than 99.5 per cent. of Hg (200.6). Preserve it in strong, well-closed containers.

Summarized Description.

Shining silver-white, liquid metal; easily divisible into spherical globules; solidifies at −40°C.; sp. gr. 13.5; insoluble in most solvents, including hydrochloric acid; soluble in boiling sulphuric acid and in nitric acid; volatilizes some at ordinary temperature and boils at 358°C. For details see U.S.P., p. 219.

For *tests for identity* and for *assay* see U.S.P., p. 220 and also Part V of this book.

Remarks.—Metallic mercury is one of the three metals recognized by the pharmacopœia as a metal, the other two being zinc and iron.

It will be noticed from the pharmacopœial description of the metal that one of the tests is that a globule of mercury rolled on paper should not leave a black mark. If it does leave a mark, it means that the mercury is contaminated with dirt, and this can be removed by straining through chamois. If there is only a small quantity of mercury to be so cleaned, it can be done by placing a plain filter in a funnel, and piercing the point of the filter with a pinhole, just large enough to permit the passage of the mercury in a very fine stream.

The globules of mercury rolling down over the paper toward the pinhole will leave most of the dirt against the paper.

It must be borne in mind, however, that this process will remove only such impurities as are insoluble, and for a complete purification of the metal its distillation is advisable. To perform this is, however, a matter of difficulty, except on a large scale, and recourse is had to purification by treatment of diluted nitric acid, washing with water, drying, and expressing through chamois.

Mercury is always given medicinally in finely divided form, and of such preparations the following are official:

MASSA HYDRARGYRI—Mass of Mercury

(Mass. Hydrarg.—Blue Mass)

It contains not less than 32 per cent. nor more than 34 per cent. of Hg. Preserve the product in well-closed containers.

Recipe and details of manufacture see Part VII.

Assay.—See Part V.

Remarks.—*Mass of mercury* is mercury extinguished (as already explained on p. 302) by honey of rose and glycerin, the excipient (a hardener in this case) being glycyrrhiza and althæa. For details of manufacture see p. 302. Mass of mercury is used as a cholagogue.

Dose.—250 milligrammes (4 grains).

HYDRARGYRUM CUM CRETA—Mercury with Chalk

(**Hydrarg. cum Cret.**—Gray Powder)

It contains not less than 37 per cent. nor more than 39 per cent. of Hg.

Condensed Recipe.

Weigh 38 Gm. mercury and 10 Gm. clarified honey into a stout bottle, add 2 mils of water and shake until the mercury is extinguished (no longer visible under glass magnifying four diameters). Make a thick creamy paste of 57 Gm. prepared chalk with water in a mortar, add to it the extinguished mercury and triturate to a uniform mixture. Dry this between layers of bibulous paper and then in a dish until it weighs 100 Gm. Then powder it; bottle and keep away from the light. For details see U.S.P.

Summarized Description.

Light gray rather damp powder, free from grit, slightly sweet taste. For details see U.S.P., p. 221.

For *tests for identity*, for *impurities* (mercurous and mercuric oxides) and for *assay* see U.S.P., p. 221 and also Part V of this book.

Remarks.—*Mercury with chalk* is a finely divided form of mercury, containing from 37 to 39 per cent. of metal extinguished by clarified honey, moist chalk being then added. Like all mercurial preparations made of the free metal, the extinguishing is the most tiresome, and in this special case can only be performed satisfactorily by machinery. In the finished product the mercury globules should not be seen with a glass magnifying four diameters. By bibulous paper the pharmacopœia means an absorbent like filter- or blotting paper.

This body is used as a cholagogue.

Dose.—250 milligrammes (4 grains).

UNGUENTUM HYDRARGYRI—Mercurial Ointment

Recipe.—See p. 332.

Outline of Assay.

Melt 10 grammes of the ointment and extract with several portions of warm purified petroleum benzin, until all of the fat is dissolved. Warm the residual mercury with diluted hydrochloric acid and stir until the mercury collects in a globule. Then warm the mercury with a little distilled water, dry it on bibulous paper and weigh. It should weigh from 4.9 to 5.1 Gm.

Ointment of mercury contains 50 per cent. of mercury, extinguished with oleate of mercury and mixed with prepared suet and benzoinated lard. (See p. 332.) It is used rather extensively in skin troubles, and also for destroying body vermin. For this latter purpose it is usually dispensed in diluted form.

UNGUENTUM HYDRARGYRI DILUTUM.—Blue Ointment

This is not the 33 per cent. ointment directed in the last pharmacopœia but contains only 30 per cent. of mercury. (See p. 333.) It is made by blending the 50 per cent. ointment with petrolatum.

In the pharmacopœia of 1890 the 50 per cent. ointment was the only one official, and its official synonym was blue ointment. Most pharmacists dispensed over the counter in answer to calls for "blue ointment" the 33 per cent. article, and under the pure food laws of the several States such substitution of a weaker product for the official was a misdemeanor.

While the 50 per cent. ointment is the one to use for obtaining the effect of mercury by inunction, the 30 per cent. is much safer to use for body vermin; hence the weaker form was introduced into the eighth edition of the pharmacopœia under the name, blue ointment.

Emplastrum Hydrargyri (U.S.P. VIII), or *mercurial plaster*, contained 30 per cent. of mercury extinguished with oleate of mercury, and then diluted with lead plaster.

Emplastrum Ammoniaci cum Hydrargyri (U.S.P. 1890).—Plaster of ammoniac and mercury, which was formerly official, contains 18 per cent. of mercury, and is made by extinguishing the metal with oleate of mercury, and combining same with an acetic acid extract of ammoniac and lead plaster.

SALTS OF MERCURY

It will be recalled, in considering iron salts, the various ferrous compounds were first discussed, and these followed by the ferric compounds. In the case of the mercury compounds, however, we can obtain a better view of the subject by comparing the two classes of salts, the "ous" and the "ic" together; hence the two chlorides will be studied together, then the two iodides, and so on.

HYDRARGYRUM AMMONIATUM—Ammoniated Mercury

(Hydrarg. Ammon.—White Precipitate)

It contains mercurammonium chloride [$HgNH_2Cl = 252.09$] corresponding to not less than 78 per cent. nor more than 80 per cent. of Hg. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, pulverulent pieces or white, amorphous powder; earthy, then styptic, metallic taste; insoluble in water or alcohol; decomposed by prolonged washing with water, changing to a yellow basic salt; soluble in warm hydrochloric, nitric or acetic acid and in ammonium carbonate solution; soluble in solution of sodium thiosulphate with decomposition; heated below redness, dissociates; at red heat, sublimes. For details see U.S.P., p. 220.

For *tests for identity*, for *impurities* (carbonate, mercurous salts) and for *assay* see U.S.P., p. 220 and also Part V of this book.

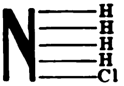
Remarks.—This compound, commonly called *white precipitate*, is made by the precipitation of the solution of mercuric chloride with ammonia water, the equation being as follows:

$$HgCl_2 + 2NH_4OH = NH_2HgCl + 2H_2O + NH_4Cl.$$

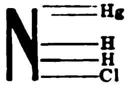
Ammoniated mercury is an interesting illustration of how a complex formula can be altered. If we add hydrochloric acid (HCl) to ammonia water (NH_4OH), we get ammonium chloride (Formula A), as already explained on p. 449.

If, however, it is mercuric chloride ($HgCl_2$) that is added to ammonia water instead of hydrochloric acid, we get ammoniated mercury, NH_2-HgCl, in which two of the hydrogen atoms of the ammonium chloride are replaced by one atom of mercury, with the valence II, as shown in Formula B.

FORMULA A



FORMULA B



Great care must be taken in the manufacture strictly to follow the pharmacopœial recipe. Several combinations of mercuric chloride with ammonia are known, and if the proportions of bichloride and ammonia water vary, some of these other than $HgNH_2Cl$ may be formed. Again, if the diluted ammonia water is poured into the bichloride solution instead of the pharmacopœial direction of the reverse procedure, we obtain a double salt, $NH_2HgClHgCl_2$. Even use of exactly the pharmacopœial amount of wash liquid is imperative, as a large excess of water will convert the precipitate to the yellow $NH_2(HgO)HgCl$.

White precipitate, when treated with alcoholic solution of iodine, produces an explosion due to liberation of ammonia and nitrogen:

$$9NH_2HgCl + 6I_2 = 3NH_4Cl + 3HgCl_2 + 2NH_3 + 2N_2 + 6HgI_2.$$

Ammoniated mercury is never used internally, being always applied in the form of an ointment. Such an ointment, containing 10 per cent. of ammoniated mercury, rubbed up with 50 Gm. melted white petrolatum and 40 Gm. hydrous wool-fat, is official under the name of *unguentum hydrargyri ammoniati.* (See p. 333.)

Sal Alembroth, $Hg(NH_4)_2Cl_4 2H_2O$, a crystalline, water-soluble salt, made by dissolving mercuric chloride and ammonium chloride in boiling water, was formerly used in medicine.

Two chlorides of mercury are recognized by the pharmacopœia—the *mercuric chloride,* $HgCl_2$, and the *mercurous chloride,* HgCl.

HYDRARGYRI CHLORIDUM CORROSIVUM—Corrosive Mercuric Chloride

(Hydrarg. Chlor. Corr.—Bichloride of Mercury—Corrosive Sublimate—Mercuric Chloride—Perchloride of Mercury)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99.5 per cent. of $HgCl_2$ (271.52). Preserve it in well-closed containers.

Summarized Description.

Heavy, colorless, rhombic crystals, or crystalline masses, or white powder; characteristic metallic taste; soluble in about 13 parts of water in about 3 parts of alcohol, in about 16 parts of glycerin and about 15.7 parts of ether; fuses at 265°C. and sublimes at about 300°. For details see U.S.P. p. 214.

For *tests for identity,* for *impurities* (insoluble matter) and for *assay* see U.S.P., p. 214 and also Part V of this book.

This is the violent poison called *corrosive sublimate,* and is made by heating a mixture of mercuric sulphate and sodium chloride in a retort. As a result, the mercuric chloride forms and sublimes, condensing in masses, while the sodium sulphate remains in the retort, as is shown in the following equation:

$$HgSO_4 + 2NaCl = HgCl_2 + Na_2SO_4.$$

It can also be made by mixing 100 parts of mercuric sulphate, 40 parts of sodium chloride and 20 parts of 5 per cent. hydrochloric acid, and after triturating to a magma and letting stand for twenty-four hours, extracting the mercuric chloride with boiling 95 per cent. alcohol.

Mercuric chloride, or *bichloride of mercury*, as it is frequently called, occurs in the form of colorless, rhombic crystals or in crystalline masses. It is used internally as an alternative, and is frequently administered in combination with potassium iodide, when mercuric iodide results.

Mercuric chloride is one of the most valuable antiseptics. If it is applied to the skin in concentrated form, it is escharotic and caustic, and for this reason great care should be taken in the use of the alcoholic solution for local application.

Bichloride of mercury is a virulent corrosive poison, producing an acute type of nephritis. Antidotes are therefore usually of service only when administered shortly after the poison has been swallowed. The standard antidote is albuminous matter (white of egg or milk) forming the comparatively inert insoluble albuminate of mercury which is removed from the stomach by use of an emetic. Lately sodium phosphite and also potassium iodide plus a non-toxic alkaloid (like quinine) have been suggested as constitutional antidotes.

So widespread has been mischief produced by careless use of "bichloride tablets" that the new pharmacopœia provides *poison tablets of corrosive mercuric chloride* (see page 318) of distinctive shape and color.

Dose.—3 milligrammes (1/20 gram).

HYDRARGYRI CHLORIDUM MITE—Mild Mercurous Chloride

(Hydrarg. Chlor. Mit.—Mercurous Chloride—Calomel—Protochloride of Mercury—Subchloride of Mercury)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99.6 per cent. of HgCl (236.06). Preserve it in well-closed containers, protected from light.

Summarized Description.

White, unpalpable powder; yellow-white on trituration under pressure; insoluble in water, alcohol, ether and cold, diluted acids; on strong heat, volatilizes without fusion. For details see U.S.P., p. 215.

For *tests for identity*, for *impurities* (mercuric chloride, ammoniated mercury) and for *assay* see U.S.P., p. 215 and also Part V of this book.

Remarks.—Two origins of the synonym *calomel* have been suggested. Both agree that the word is derived from the Greek word *kalos*, meaning good, and *melas*, meaning black. Some explain these words (black, good) by saying that it means that calomel was good for black bile, while others claim that it is because of the fact that calomel blackens when treated with ammonia.

As explained on p. 550, some chemists claim that calomel has the formula HgCl, while others think it is Hg_2Cl_2.

Calomel is made by a process similar to the manufacture of corrosive sublimate—*i.e.*, the mercuric sulphate is prepared by treatment of mercury with sulphuric acid, and to the mass sodium chloride is added, but before subliming there is also added an amount of mercury equal to the quantity originally used to make the mercuric sulphate. The mixture is then sublimed, as in the case of corrosive sublimate, for, be it remembered, calomel is sublimable, even as is the so-called "sublimate" ($HgCl_2$). The equation of manufacture is as follows:

$$HgSO_4 + Hg + 2NaCl = 2HgCl + Na_2SO_4.$$

The two chlorides, calomel and corrosive sublimate, afford a vivid picture of the possible immense alteration in therapeutic or physical condition that a slight chemical difference may produce.

Between the insoluble, comparatively harmless calomel, and the soluble and virulent poison, corrosive sublimate, the only chemical difference is that the former contains more mercury than does the latter. The quantity of mercury in each is best shown by the following estimation of percentage composition of the two salts:

CORROSIVE SUBLIMATE	CALOMEL
$Hg = 1 \times 200 = 200$	$Hg_2 = 2 \times 200 = 400$
$Cl_2 = 2 \times 35.5 = 71$	$Cl_2 = 2 \times 35.5 = 71$
Molecular weight, $HgCl_2$, 271	Molecular weight, Hg_2Cl_2, 471

From this it will be seen that while corrosive sublimate is $^{200}/_{271}$, or 73.4 per cent., mercury, calomel contains $^{400}/_{471}$, or 84.9 per cent., mercury.

Since calomel and corrosive sublimate are both sublimable and are prepared by similar processes, there is always a possibility of the calomel containing traces of corrosive sublimate, and for this reason the pharmacopœial test should be applied to all samples of calomel. This test consists in shaking the sample of calomel with ether (in which it is insoluble, but which will dissolve the bichloride), evaporation of the ethereal solution, taking up residue with water, and testing water solution for bichloride either with silver nitrate or ammonium sulphide.

A simpler, though not exact, test was provided in U.S.P. 1890, namely, that calomel is totally insoluble in water, whereas, if there is any bichloride present, it will readily dissolve in water. Therefore on mixing calomel with water, the water, on being filtered, will contain bichloride, if any be present in the calomel, and can be detected by treating with ammonia and hydrogen sulphide.

Mild mercurous chloride is a valuable hepatic stimulant and alterative. In former days very large doses of calomel were given, ten grains being considered an average dose. It has been discovered, however, that small doses frequently repeated act far better than single large doses. For this reason at present this chemical is usually administered in ⅛- to ½-grain doses every two hours. It must be remembered that if a patient who has taken calomel is permitted to consume food containing free acids, such as lemonade, etc., that form of mercurial poisoning called salivation ensues. Hence when calomel is administered, the patient should always be warned to avoid the use of such acids until the chemical has completely acted.

A favorite method of administration of calomel is in combination with an alkali, preferably sodium bicarbonate. Large quantities of this combination are consumed in the southern States, and it might be stated that pills containing 2½ grains each of calomel and sodium bicarbonate have enjoyed considerable vogue under the name of *Dr. Stone's Little Giant Pills.* Two of these were considered a dose.

For many years, it was supposed that when calomel was triturated with sugar or with alkaline chlorides, corrosive sublimate was produced. The investigations of Schaefer (1910) indicates, however, that this is not so.

Dose.—Laxative, 150 milligrammes (2 ½ grains). Alterative, 15 milligrammes (¼ grain).

Hydrargyri Cyanidum (U.S.P. 1890).—Mercuric cyanide, $Hg(CN)_2$. This chemical is made by passing hydrocyanic acid gas into a liquid in which finely divided mercuric oxide is suspended. The hydrocyanic acid used is generally produced by treatment of potassium ferrocyanide with sulphuric acid.

Mercuric cyanide occurs in colorless prismatic crystals, turning dark on exposure to air, and is used as an alterative in syphilis, administered in doses of from 4 to 8 milligrammes.

Two iodides of mercury are recognized by the pharmacopœia—*mercuric iodide*, HgI_2, and *mercurous iodide*, HgI.

HYDRARGYRI IODIDUM RUBRUM—Red Mercuric Iodide

(**Hydrarg. Iod. Rub.**—Biniodide of Mercury—Mercuric Iodide—Red Iodide of Mercury)

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of HgI_2 (454.44). Preserve it in well-closed containers, protected from light.

Summarized Description.

Scarlet-red amorphous powder; almost insoluble in water; soluble in about 93 parts of alcohol, in about 86 parts of ether, in aqueous solutions of iodides, of mercuric chloride and of sodium thiosulphate. On heating, it becomes yellow, then fuses, and then sublimes; reduced on heating with potassium hydroxide and sugar of milk solution. For details see U.S.P., p. 216.

For *tests for identity*, for *impurities* (soluble mercury salts) and for *assay* see U.S.P., p. 217 and also Part V of this book.

Remarks.—This substance is made by the double decomposition of mercuric chloride and potassium iodide, avoiding excess of either reagent, as mercuric iodide is soluble in solutions of either chemical. This reaction takes place in many prescriptions, as the combination is a favorite one in syphilis, and, as in all such prescriptions, the iodide is largely in excess, the precipitate formed invariably redissolves. A redissolved solution of the red iodide in potassium iodide is called "*Mayer's reagent*," the proportions being 13.55 Gm. mercuric chloride, 49.8 Gm. potassium iodide, and water to make 1000 mils. As cited on p. 797, this is an alkaloidal precipitant, so look out for prescriptions calling for corrosive sublimate, potassium iodide, and some tincture, or other preparation containing alkaloids, as the Mayer's reagent formed will surely precipitate the alkaloid.

A similar preparation is *Channing's solution*, a recipe for which is given in the National Formulary. (See p. 190.)

The red mercuric iodide is used as an alterative in the case of syphilis. It is now frequently administered by intravenous injection in an oleaginous base. Thus the French Codex prescribes a red iodide oil made from 0.2 gramme of red mercuric iodide in 46 grammes of sterilized olive oil.

As mentioned above, the physiologic effects of red mercuric iodide are obtained by prescribing a combination of potassium iodide with bichloride of mercury. Red mercuric iodide is a constituent of Donovan's solution. (See p. 186.)

Dose.—3 milligrammes (1/20 grain).

HYDRARGYRI IODIDUM FLAVUM—Yellow Mercurous Iodide

(**Hydrarg. Iod. Flav.**—Mercurous Iodide—Protoiodide of Mercury—Yellow Iodide of Mercury

It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of HgI (327.52). Preserve it in well-closed containers, protected from light.

Summarized Description.

Bright yellow, amorphous powder; exposed to light, dissociates into mercury and mercuric iodide and turns greenish; almost insoluble in water; insoluble in alcohol and ether; on heating, it turns orange then red and finally volatilizes; quick heat causes partial dissociation into mercury and mercuric iodide. For details see U.S.P., p. 216.

For *tests for identity*, for *impurities* (mercuric iodide) and for *assay* see U.S.P., p. 216 and also Part V of this book.

Remarks.—This chemical was called the *green iodide of mercury* in the pharmacopœia of 1880. It is made by dissolving mercury in a sufficient quantity of nitric acid to form a solution of mercurous nitrate, the equation being as follows:

$$6Hg + 8HNO_3 = 6HgNO_3 + 4H_2O + N_2O_3.$$

The resulting solution of mercurous nitrate is then treated with a molecular quantity of potassium iodide, when potassium nitrate and mercurous iodide result, the latter being precipitated in the form of yellow, crystalline powder, the equation being as follows:

$$HgNO_3 + KI = HgI + KNO_3.$$

The product thus made is not the same as the green iodide of the pharmacopœia of 1880, which was made by the direct union of mercury with iodine, triturating the two in the presence of alcohol. The equation of this reaction was supposed to be as follows:

$$Hg + I = HgI,$$

but, as a matter of fact, it partly runs as follows:

$$Hg + I_2 = HgI_2,$$

with the formation of mercuric iodide. This mercuric iodide was removed by the process of the pharmacopœia of 1880 by washing the mixture with alcohol.

Mercurous iodide, like mercuric iodide, is used as an alterative, but is a much milder preparation, as is shown by the doses.

Dose.—10 milligrammes (1/6 grain).

While the two iodides are mercurous and mercuric respectively, both *oxides of mercury* are "ic" salts, having the formula HgO, and giving an interesting example of physical difference of two bodies that are chemically identical. Their mutual identity is proved by the fact that red oxide, when finely triturated, turns yellow, while the yellow, on heating, is converted into the red.

HYDRARGYRI OXIDUM FLAVUM—Yellow Mercuric Oxide

(Hydrarg. Oxid. Flav.)

It contains, when dried to constant weight at 150°C., not less than 99.5 per cent. of HgO (216.60). Preserve it in well-closed containers, protected from light.

Summarized Description.

Light orange-yellow amorphous, heavy, impalpable powder; somewhat metallic taste; turns somewhat dark on exposure to light; almost insoluble in water; insoluble in alcohol; soluble in diluted hydrochloric or nitric acids; on heating, it first turns red and then dissociates into oxygen and metallic mercury. For details see U.S.P., p. 217.

For *tests for identity*, for *impurities* (red mercuric oxide) and for *assay* see U.S.P., p. 217 and also Part V of this book.

Remarks.—Yellow mercuric oxide is made by treating bichloride of mercury with the requisite amount of sodium hydroxide as shown in the following equation:

$$HgCl_2 + 2NaOH = HgO + H_2O + 2NaCl.$$

As a result, mercuric oxide is precipitated, leaving in solution sodium chloride, the last traces of which are removed from the mercuric oxide by washing with water.

Yellow mercuric oxide is used chiefly externally, and that in the form of a 10 per cent. ointment (see p. 333), or of a 25 per cent. solution in oleic aicd. (See Oleate of Mercury on p. 214.)

HYDRARGYRI OXIDUM RUBRUM—Red Mercuric Oxide

(Hydrarg. Oxid. Rub.—Red Precipitate)

It contains, when dried to constant weight at 150°C., not less than 99.5 per cent. of HgO (216.60). Preserve it in well-closed containers, protected from light

Summarized Description.

Heavy, orange-red, crystalline scales or crystalline powder, turning yellow on trituration; somewhat metallic taste; almost insoluble in water; insoluble in alcohol; soluble in diluted nitric acid; makes opalescent solution with a diluted nitric acid; on heating becomes dark violet, then black; at red heat dissociates into oxygen and mercury. For details see U.S.P., p. 218.

For *tests for identity*, for *impurities* (yellow oxide of mercury, nitrate) and for *assay* see U.S.P., p. 218 and also Part V of this book.

Remarks.—Red mercuric oxide is called "*red precipitate*," but is no longer prepared by precipitation, the name being a souvenir of alchemistic days, when it was made by "upward precipitation," being formed in mercury kept near its boiling-point for weeks at a time.

It is now made by treating mercury with nitric acid (equation *a*) and heating the resulting mercuric nitrate to redness (equation *b*):

$$(a)\ 3Hg + 8HNO_3 = 3Hg(NO_3)_2 + 4H_2O + N_2O_2.$$
$$(b)\ 2Hg(NO_3)_2 + \text{heat} = 2HgO + 2N_2O_4 + O_2.$$

It will be seen from the above equations that the nitrate is dissociated into mercuric oxide, N_2O_4, and oxygen, and experience has shown that the two gases are capable of converting into mercuric oxide an amount of mercury equal to the amount of the nitrate used originally. It will be noted that the pharmacopœia gives no directions for the manufacture of this compound by the pharmacist, although it does direct the preparation of the yellow mercuric oxide. The reason for the omission of the recipe for the red mercuric oxide is because its manufacture is scarcely practical on a small scale, it being found that at the heat necessary to convert the nitrate into the oxide a very large amount of mercury is lost by volatilization.

Red mercuric oxide is used almost entirely externally, and that chiefly in the form of an ointment for granulated eyelids.

The National Formulary recognizes a 10 per cent. ointment in which the red oxide has been carefully levigated with water, and then rubbed with hydrous wool-fat and petrolatum. (See p. 337.)

Hydrargyri Subsulphas Flavus (U.S.P. 1890.)—The formerly official *yellow mercuric subsulphate* is a basic salt. As already explained on p. 513, "sub" salt is a combination of a metallic salt with its oxide, and in the case under consideration we find the relationship clearly shown in the symbolic formula, $HgSO_4(HgO)_2$. It is called *Turpeth mineral*, on account of its resemblance to the powdered turpeth root, the root of *Ipomœa turpethum*, which was formerly used in medicine.

Turpeth mineral is made by treating mercury with a mixture of sulphuric acid and nitric acids, whereby mercuric sulphate is formed, as shown in the following equation:

$$3Hg + 3H_2SO_4 + 2HNO_3 = 3HgSO_4 + 4H_2O + N_2O_2.$$

The white mercuric sulphate is then heated with a large quantity of water, whereby it is converted into the yellow mercuric subsulphate, as shown in the following equation:

$$3HgSO_4 + 2H_2O = HgSO_4 2HgO + 2H_2SO_4.$$

Turpeth mineral is an alterative, possessing, however, such irritating qualities as to render its general use unsafe. It is administered in doses of from 16 to 30 milligrammes.

Mercuric nitrate, $Hg(NO_3)_2$, is not recognized by the pharmacopœia as a chemical itself, but two preparations containing this body have extended use.

Liquor Hydrargyri Nitratis (U.S.P. VIII; N.F. IV) or *solution of mercuric nitrate* is made by dissolving 40 grammes of mercuric oxide in a mixture of 45 grammes of nitric acid and 15 grammes of distilled water. It is a very heavy fluid, weighing more than twice as much as water (sp. gr. 2.086).

Solution of mercuric nitrate is used entirely locally as a corrosive in syphilitic sores.

UNGUENTUM HYDRARGYRI NITRATIS—Mercuric Nitrate Ointment

Recipe and details of manufacture in Part VII.

The *ointment of mercuric nitrate* (called *citrine ointment*) is made by dissolving mercury in nitric acid, and, at the same time, heating lard to 45°C., adding thereto a portion of the nitric acid. When the nitric acid is added to the heated lard, a rather violent chemical action takes place, with the conversion of the oleate of glyceryl, which is the chief constituent of the lard, into elaidin. (See p. 652.)

Mercury is dissolved in the rest of the nitric acid, forming mercuric nitrate, and it might be said in passing that when mercury is dissolved in nitric acid we get mercurous or mercuric nitrate, according to the relative proportions of mercury and nitric acid employed:

$$3Hg + 8HNO_3 = 4H_2O + N_2O_2 + 3Hg(NO_3)_2 \text{ (Mercuric nitrate).}$$
$$6Hg + 8HNO_3 = 4H_2O + N_2O_2 + 6HgNO_3 \text{ (Mercurous nitrate).}$$

That the proportions of mercury and nitric acid used in the official recipe yield mercuric nitrate is shown by the molecular weight calculations relating to citrine ointment found in Practical Work (p. 1008).

It may be well to sum up here the effect of various acids on metals.

Hydrochloric and *other haloid acids* and *diluted sulphuric acid* give, with metals the appropriate salt, *with the evolution of hydrogen.* Example:

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$

Nitric acid, either concentrated or diluted, and *concentrated sulphuric acid,* give with metals the appropriate salt, with the *evolution of N_2O_2* or *N_2O_4,* in the case of nitric acid, and of SO_2 in the case of sulphuric acid. Examples of nitric acid are given just above. Of concentrated sulphuric acid, see Copper Sulphate (p. 537).

Citrine ointment (from *citrus,* the lemon) has, as the name suggests, a bright yellow color when freshly prepared; on standing, however, it assumes a brown tint. The manufacture of this compound is one calling for considerable skill in order to obtain a product of exactly the right color and consistence and of the same quality. The quality of lard oil found in the market was so variable that, in the eighth revision of the pharmacopœia, the lard oil of U.S.P. 1890 was replaced by the more reliable lard.

Citrine ointment is a valuable remedy for certain forms of skin trouble, such as tetter and ring-worm.

HYDRARGYRI SALICYLAS—Mercuric Salicylate

(**Hydrarg. Salicyl.**—Mercuric Subsalicylate)

A compound of mercury and salicylic acid containing not less than 54 per cent. nor more than 59.5 per cent. of Hg. Preserve it in well-closed containers protected from light.

Summarized Description.

White, slightly yellowish or slightly pinkish powder; nearly insoluble in water or alcohol; soluble in warm solutions of alkali halides. For details see U.S.P., p. 219.

For *tests for identity*, for *impurities* (free salicylic acid, foreign mercury compounds) and for *assay* see U.S.P., p. 219 and also Part V of this book.

Remarks.—This new official is prepared by heating a freshly precipitated yellow mercuric oxide with the molecular quantity of salicylic acid and with a little water until a perfectly white mixture results. It is a white powder, insoluble in water and is used as an antiseptic and antisyphilitic. For the latter purpose it is usually injected in the form of a suspension in oils.

Dose.—4 milligrammes (1/15 grain).

Mercuric Sulphide (U.S.P. 1880) is the artificial *cinnabar*, and is made by the sublimation of the black sulphide. The latter, formerly called *Æthiops mineral*, has been mentioned as the precipitate formed by passing hydrogen sulphide through solutions of mercuric salts, but is made commercially by fusing sulphur with mercury. Both sulphides have the formula HgS, the only difference being that the red is crystalline, while the black is amorphous. Cinnabar is practically never used internally.

SILVER

Symbol, Ag. Atomic weight, approximately 108

Silver occurs occasionally in the form of the pure metal, but its most abundant ores are silver sulphide, which is called *silver glance*, and the chloride, or *horn silver*. A very large quantity of silver is obtained from the silver-bearing galena. (See p. 544.)

Silver is one of the ancient metals, reference to it being found in the earliest writings. Silver salts were also known to the ancient Egyptians, since some mummy clothes are marked with indelible (silver nitrate) ink. The Latin word *argentum* is derived from the Greek for silver, *arguros*, which is in turn derived from the Greek word *argos*, meaning white. It is worth the matter of passing interest that in several languages the word silver is similar to the word white, and we know that, in this country, we sometimes speak of silver as the white metal, in contradistinction to gold, "the yellow metal."

The *metallurgy* of silver is interesting and important, and can be roughly divided into four groups. The first include the wet extraction process. In one of these the sulphides (galena or silver glance) is roasted with sodium chloride, thus changing the silver to silver chloride. The roasted mass is then ground, placed in appropriate hoppers, percolated with an aqueous solution of sodium thiosulphate, in which the chloride is soluble; calcium sulphide is added to the percolate, causing the precipitation of silver sulphide.

The pure silver is obtained by roasting the sulphide, while the thiosulphate is recovered from the filtrate and used again.

Another method is by carefully roasting the ores, whereby the silver sulphide contained therein is converted into sulphate, and this is extracted by percolation of the roasted mass with water. Metallic silver is separated from the percolate by use of metallic copper.

The second group of processes are those where *amalgamation* is employed. In these the ore is roasted with salt, changing the silver sulphide found therein to silver chloride. This is reduced with iron or with copper sulphate to metallic silver, which forms an amalgam with mercury. This amalgam is separated from the solid matter and is heated in a retort, when the mercury distils, leaving a residue of metallic silver.

The third group of processes are those where *cupellation* is employed, and is applied to ores containing lead and silver. Such ores are roasted in furnaces with free exposure to air, the result being the liberation of metallic silver and the conversion of lead into litharge, which is skimmed off. Lastly, *electrolytic separation* of silver from copper-bearing ores is now being employed.

Silver is a brilliant white metal, malleable, ductile, soluble in nitric acid, and but sparingly soluble in sulphuric acid. While in the molten condition it has a great affinity for oxygen, absorbing no less than twenty-two times its volume of that gas. On cooling, it parts with all its oxygen, and frequently with explosive violence. This property makes the melting of silver a process requiring considerable care. The silver used in coins consists of 90 per cent. of silver and 10 per cent. of copper, it being so admixed because pure silver is too soft to be used alone.

Silver is called a "noble metal," partly because it costs more than the common metals already considered, and chiefly because it withstands the oxidizing action of the atmosphere. This property it shares with gold and platinum and is noted in a lesser degree in aluminum and nickel.

The *tests* for silver are as follows:

Hydrochloric acid produces a precipitate of white silver chloride, insoluble in nitric acid, but soluble in ammonia water. Hydrogen sulphide or ammonium sulphide produces a black precipitate of silver sulphide, while potassium hydroxide precipitates silver from its soluble salts in the form of a brown silver oxide.

The oxides of silver which are known are Ag_2O, Ag_2O_2, and Ag_4O. Of these, the first is the only one of sufficient importance to merit more than passing notice. It is recognized by the pharmacopœia, and in constitution is analogous to sodium oxide, Na_2O, exhibiting silver with valence I.

The official salts of silver are:

Silver nitrate. At least 99.8 per cent. absolute $AgNO_3$.
Fused silver nitrate. At least 94.5 per cent. absolute $AgNO_3$.
Silver oxide. At least 99.6 per cent. absolute Ag_2O.

In considering these, the nitrate will be the first taken up, since from it all the other official silver compounds are made.

ARGENTI NITRAS—Silver Nitrate

(Arg. Nit.)

It contains, when finely powdered and dried to constant weight in a desiccator over sulphuric acid, in the dark, not less than 99.8 per cent. of $AgNO_3$ (169.89). Preserve it in dark amber-colored vials, protected from light.

Summarized Description.

Colorless, tabular, rhombic crystals; turns gray or grayish black on exposure to light; bitter, metallic taste; very caustic; soluble in 0.4 part of water and in 24 parts of alcohol; slightly soluble in ether; on heating to 200° it melts; at higher heat it dissociates. For details see U.S.P., p. 61.

For *tests for identity*, for *impurities* (copper) and for assay see U.S.P., p. 61 and also Part V of this book.

Remarks.—This salt is made by dissolving silver coin in nitric acid, evaporating the solution to dryness, fusing, adding water to the fused mass, and filtering the silver nitrate solution from the copper oxide residue.

Silver coin is far more accessible than pure silver, hence is employed in making the nitrate. But in this process not only does the silver unite with the acid to form the nitrate, but, likewise, the copper forms copper nitrate, and, of course, a silver nitrate containing copper nitrate would not answer. The copper is removed in a very ingenious way. Silver nitrate melts unchanged at 200°C., and at that temperature copper nitrate is decomposed into the gaseous oxides of nitrogen and into copper oxide, which remains behind, an insoluble mass. The fused mass is treated with water, in which the silver nitrate dissolves, leaving copper oxide behind.

It will be noted, from the pharmacopœial description given above, the solution of silver nitrate turns black on exposure to light, if organic matter is present. This is due to the separation of metallic silver, under the reducing action of sunlight. All silver salts are very sensitive to the action of light; most of all, silver bromide, and the blackening of silver bromide by the influence of light constitutes the foundation of the art of photography.

Stains of silver nitrate on the skin can be removed by painting with tincture of iodine (thus producing silver iodide) and then removing the latter stain with a solution of sodium thiosulphate.

Silver nitrate is a very valuable remedy, used both externally and internally. It is used internally in cases of gastritis and diarrhea in small doses, while large quantities act as a caustic and escharotic. If given in an overdose, the antidote is sodium chloride, which produces a mild and comparatively inert silver chloride. Externally, it is of considerable value as a caustic, but the application should be made with great care. For external use two other forms of silver nitrate are emloyed, the fused and the diluted.

Dose.—10 milligrammes (1/6 grain).

ARGENTI NITRAS FUSUS—Moulded Silver Nitrate

(Arg. Nit. Fus.—Fused Silver Nitrate—Lunar Caustic)

It contains not less than 94.5 per cent. of $AgNO_3$ (169.89).

Condensed Recipe.

Add 4 Gm. hydrochloric acid to 100 Gm. silver nitrate, melt in a porcelain dish and pour into suitable molds.

Summarized Description.

White, hard solid, usually in the form of pencils or cones; fibrous fracture; turns gray or grayish black on exposure to light; bitter, strongly metallic taste; very caustic; soluble (except 5 per cent. of silver chloride) in 0.4 part of water and 24 parts of alcohol; slightly soluble in ether. For details see U.S.P., p. 62.

For *tests for identity*, for *impurities* see silver nitrate.

Remarks.—Fused silver nitrate is made by melting silver nitrate in a porcelain capsule, adding thereto 4 per cent. of hydrochloric acid, and pouring the melted mixture into suitable molds. The hydrochloric acid used in this case is for the purpose of rendering the silver nitrate tougher and less brittle by the formation of a small quantity of silver chloride.

The melted silver nitrate is called *lunar caustic* (from *luna*, Latin for moon), and the application in this case is an interesting relic of alchemistic nomenclature. The alchemists, the forerunners of the modern chemists, assigned to the commoner metals the names of the heavenly bodies and of the gods of Roman mythology. Thus, gold was the sun; silver, the moon (luna); iron was Mars; copper was Venus; lead was Saturn; while quicksilver was, as it is now, mercury. In old names that are still used—like "boule de Mars" (iron and potassium tartrate), "*acetum Saturni*" (solution of lead subacetate), and "lunar caustic"—we find these terms still existing.

Molded silver nitrate is also called *lapis infernalis* (*stone of Hell*).

Argenti Nitras Mitigatus (U.S.P. VIII), or *mitigated caustic*, is made by melting together 30 parts of silver nitrate and 60 parts of potassium nitrate. As silver nitrate is a very powerful caustic, it is sometimes found wise to apply it in this diluted form.

Argenti Cyanidum (U.S.P. VIII), or *silver cyanide*, AgCN, is made by passing hydrocyanic gas through a solution of silver nitrate. It can also be made by treating potassium cyanide with silver nitrate.

It affords a simple method of extemporaneous preparation of diluted hydrocyanic acid. This acid is quite unstable, and should be fresh when dispensed. This rule is easily followed if the acid is made from silver cyanide and hydrochloric acid, the hydrocyanic acid that is formed remains in solution, while the silver chloride separates out and can be filtered off.

Argenti Iodidum (U.S.P. 1890), or *silver iodide*, is made by combining a solution of potassium iodide and silver nitrate and collecting the precipitated silver iodide, as shown in the following equation:

$$KI + AgNO_3 = KNO_3 + AgI.$$

This is a heavy yellow powder, and is used as an alterative in syphilis, in doses of 0.03 to 0.12 Gm. (½ to 4 grains).

There is some demand for silver iodide in emulsified form and this can be prepared by dissolving the molecular quantity of potassium iodide in a 0.3 of 1 per cent. solution of gelatin and adding to this, little by little, the proper quantity of silver nitrate in aqueous solution. The proportional amounts are obviously 165 parts of potassium iodide to 169 parts of silver nitrate.

ARGENTI OXIDUM—Silver Oxide

(Arg. Oxid.)

It contains, when dried to constant weight at 120°C., not less than 99.6 per cent. of Ag_2O (231.76). Preserve it in well-stoppered, dark amber-colored vials. It must not be triturated with readily oxidizable or combustible substances, and must not be brought in contact with ammonia.

Summarized Description.

Heavy, dark, brownish-black powder; reduced by exposure to light; metallic taste; very slightly soluble in water; insoluble in alcohol; completely soluble in nitric acid; dissociates on heating from 250° to 300°C. into oxygen and metallic silver. For details see U.S.P., p. 62.

For *tests for identity*, for *impurities* (chloride, copper) and for *assay* see U.S.P., p. 63 and also Part V of this book.

Remarks.—Silver oxide is prepared by precipitating silver nitrate solution with potassium hydroxide solution, as shown in the following equation:

$$2AgNO_3 + 2KOH = Ag_2O + 2KNO_3 + H_2O.$$

Silver oxide must be carefully handled, owing to its energetic oxidizing action, hence the pharmacopœial warning given above.

The only way safely to make pills of silver oxide is by using petroleum mass or kaolin and vaselin as excipient. (See p. 305.) Also beware of bringing it in contact with ammonia, for the two will form the dangerous explosive, fulminating silver.

Silver oxide is one of the most valuable compounds of silver for internal use, it being far less caustic than any of the other silver compounds.

Dose.—60 milligrammes (1 grain).

Colloidal silver preparations have been extensively used of late in place of silver nitrate and silver oxide. These are based on the remarkable fact that if a soluble silver salt is reduced under proper conditions, the metallic silver thus produced is water-soluble, due, it is claimed to the fact, that the metal is in such finely divided form (possibly in molecular condition) that a colloidal solution (p. 154) obtains. Colloidal silver can be prepared by adding to 10 per cent. silver nitrate solution 30 per cent. ferrous sulphate solution, 40 per cent. sodium citrate solution and 10 per cent. sodium carbonate solution. A lilac precipitate containing 97 per cent. of silver results and this after washing free from impurities with ammonia citrate solution is soluble in water or 10 per cent. sodium chloride solution.

Commercial products are usually prepared containing small amounts of proteids, such compounds having been found to yield more stable solutions. Among the proprietary forms of colloidal silver may be cited *protargol* and *argyrol*. These are now used largely in the form of glycerinic solutions for throat troubles.

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PART IV

ORGANIC CHEMISTRY

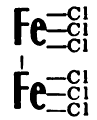
CHAPTER XXXV

INTRODUCTION

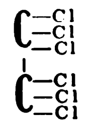
ORGANIC chemistry is the study of the carbon compounds, the adjective "organic" being a survival of the earlier days of chemical thought, when it was supposed that all substances peculiar to animal and vegetable economy—such bodies as those about to be discussed—were produced by the action of a mysterious influence called the force of life—"*vis vitæ.*" Although this vis vitæ theory was exploded in 1828 by Woehler's synthesis of urea (p. 677), the name "organic chemistry" is still applied to the carbon compounds.

Essential to an organic compound are the carbon atoms it contains, and it is interesting to note that in all the numberless derivatives of carbon (some 112,000 now known to the practice) these carbon atoms always show the valence IV, just as do the carbon atoms in the carbonates discussed in previous chapters.

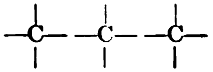
The reason why carbon forms so many compounds is because it possesses, to a far greater extent than any other element, the property of using some of its bonds for linking itself to adjoining carbon atoms. That one atom of an element is capable of attaching itself to another atom of the same element has been already shown, for example, in the formula Fe_2Cl_6 (p. 503), the graphic formula showing that two atoms of iron are directly attached to each other. Likewise in Hg_2Cl_2 the two mercury atoms are attached to each other by their own bonds. Returning to the question of ferric chloride, it will be remembered that its formula was explained by the statement that we had iron with the valence IV, and with a bond of each iron atom used for attaching itself to the other, as shown in graphic formula:



Exactly analogous to ferric chloride is the formula of ethane, that carbon compound containing two atoms, and, as a matter of fact, there is known a body C_2Cl_6, exactly analogous to Fe_2Cl_6:



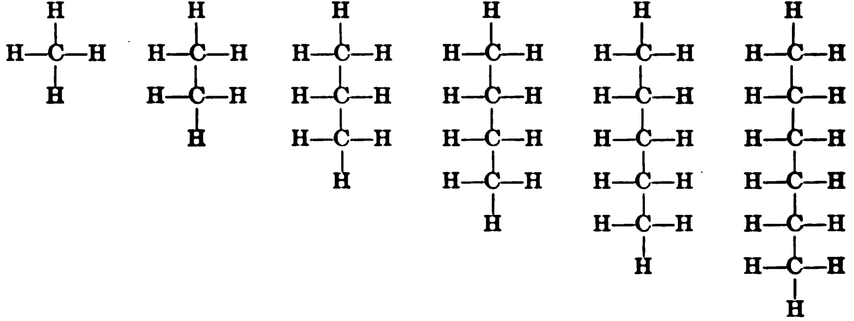
These two carbon atoms, however, can link on a third carbon atom, making a chain of three carbon atoms, which can be graphically represented as:



$$\begin{array}{ccccccccc} & | & & & | & & & | & \\ — & C & — & — & C & — & — & C & — \\ & | & & & | & & & | & \end{array}$$

And in this way there can be devised chains containing four, five, or six carbon atoms, making the following series:

METHANE.	ETHANE.	PROPANE.	BUTANE.	PENTANE.	HEXANE.
CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}



This series can be continued almost indefinitely, similar chains containing 60 carbon atoms being known.

These compounds are composed only of carbon and hydrogen, and are called *hydrocarbons*. They all belong to a similar set or series, and the members of such a series are called *homologues*. In this series of homologues the carbon atoms are linked into a long string or chain, and the series is called the *chain series* of hydrocarbons. Because these hydrocarbons and their derivatives are found in fats, the series is sometimes called the *fatty series*.

Among the members of the series there exists a mathematic relationship between the relative number of carbon and hydrogen atoms.

This relationship can be expressed in the mathematic formula C_nH_{2n+2}, which means twice the number of carbon atoms, plus two, gives the number of hydrogen atoms.

Let us prove this:

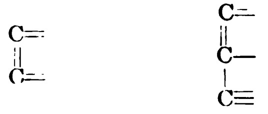
Take methane, CH_4. There is one carbon—C_n means C.
H_{2n+2} means $2 \times 1 = 2$; $2 + 2 = 4$, H_{2n+2} means H_4.

So with ethane, C_2H_6. C_n means C_2.
H_{2n+2} means $2 \times 2 = 4$; $4 + 2 = 6$, H_{2n+2} means H_6.

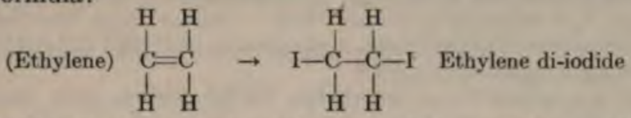
Likewise with propane, C_3H_8. In this case C_n means C_3.
H_{2n+2} means $2 \times 3 = 6$; $6 + 2 = 8$, H_{2n+2} means H_8.

Lastly the hydrocarbon, $C_{60}H_{122}$. In this case C_n means C_{60}.
H_{2n+2} means $2 \times 60 = 120$; $120 + 2 = 122$; H_{2n+2} means H_{122}.

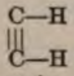
In methane, ethane, propane, and the other hydrocarbons, possessing the general formula C_nH_{2n+2}, the carbon atoms are arranged in a chain, that is, one linked after another, like beads on a string. Another variety of chain hydrocarbons are those having the formula C_nH_{2n}, of which ethylene and propylene are the types. These bodies are unsaturated, that is, at least two of the carbon atoms of the compound are linked together by means of double bonds, as outlined in the graphic formula:

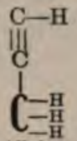


These are said to be unsaturated, because the double bonds split whenever opportunity is presented for them to be used for attaching other elements to the carbon atom. Thus, if ethylene is treated with iodine, the double bond is immediately severed and an iodine atom is attached to each bond, making ethylene di-iodide, as shown in the following graphic formula:



Another series of chain hydrocarbons is the acetylene series, in which adjoining carbon atoms are connected by a triple bond, as shown in acetylene and allylene, graphic formulas of which are given:


Acetylene.


Allylene

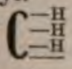
Besides these chain series of hydrocarbons, we have a series of hydrocarbons of which benzene, C_6H_6, is the type, in which the carbon atoms form a ring, as explained on p. 686. This series is called the aromatic series, in contradistinction to the fatty series of chain hydrocarbons just cited.

Radicles are atomic groups, either organic or inorganic, not existing in a free state, but assigned names, and temporarily considered as entities, merely for convenience.

Chemists run across scores of chemical compounds containing the group, say, C_2H_5 (examples: C_2H_5OH, or alcohol; $(C_2H_5)_2O$, or ether, etc.), and as many others containing, say, COOH. Neither C_2H_5 nor COOH exists in a free state, but since we meet them so often in compounds, we give them names. Thus, we call C_2H_5 "*ethyl*," simply because it is much easier to say "ethyl" than to call the compound "two atoms of carbon and five atoms hydrogen," and for similar reason we call COOH "*carboxyl*." Such atomic groupings are called radicles.

In methane, CH_4, we have a body in which all the bonds of the carbon are taken up by hydrogen. In all known bodies the employment of all the bonds of the carbon atoms, in some way or other, is distinctly noticeable, and carbon compounds having free bonds do not exist.

As already mentioned, free atoms do not exist; yet free atoms enter into chemical combinations. Such is the case with what are called radicles, and of these, we may take as example the group CH_3, which we call methyl.

Note that  has a free bond, hence it does not exist in a free state. But as it enters into chemical reactions, we may consider it just as we do atoms.

For instance, just as sodium (Na) and chlorine (Cl) join to form sodium chloride (NaCl), so is obtained CH_3Cl, which is called methyl chloride.

Just as the radicle CH_3 is considered as a derivative of CH_4, so from C_2H_6 is derived the radicle *ethyl*, C_2H_5, and from C_3H_8 the radicle C_3H_7, which is called *propyl*.

Another similarity between atoms of elements and radicles.

Elements are divided into positive and negative, according as their action resembles metals or non-metals.

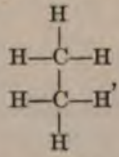
The radicles mentioned thus far are all typical of a character somewhat similar to metals, since each (CH_3, for example) combines with chlorine, just as sodium or iron does. Others there are that act like the negative part of the molecule; such groups as (OH), (COOH), and (CHO) resembling negative elements.

But too much trust must not be placed on this idea of radicles, as the following facts show that they should be considered more as a convenient figure of speech than as definite chemical entities.

Na, the atom of sodium, does not exist. Na_2, the molecule, does (graphically expressed, Na—Na), the atoms linked "hand in hand."

Methyl, the radicle CH_3, does not exist; $(CH_3)_2$ does, but as a body entirely different from the hypothetic methyl, from which it is derived.

$CH_3—CH_3$ is



$$\begin{array}{c} H \\ | \\ H—C—H \\ | \\ H—C—H \\ | \\ H \end{array}$$

, C_2H_6 (Ethane),

which, when brought in contact with chlorine, does not form CH_3Cl (as Na_2 treated with chlorine yields NaCl), but the product is C_2H_5Cl.

Another difference is that the atom of an element is unchangeable; methyl, the radicle, can be modified from $(CH_3)^I$ to $(CH_2Cl)^I$, $(CHCl_2)^I$, or $(CCl_3)^I$, and exactly so with all other radicles.

The Roman numeral outside the brackets in each formula means that the radicles have as many free bonds as the numeral indicates.

Further discussion of radicles is beyond the limits of this book, and in conclusion there will only be added the statement that the name of each radicle is given the termination "*yl.*"

The following are the more important radicles:

POSITIVE				NEGATIVE	
Methyl	$(CH_3)^I$,	from methane,	CH_4.	Hydroxyl	$(OH)^I$.
Ethyl	$(C_2H_5)^I$,	from ethane,	C_2H_6.	Carboxyl	$(COOH)^I$.
Propyl	$(C_3H_7)^I$,	from propane,	C_3H_8.	Carbonyl	$(CO)^{II}$.
Butyl	$(C_4H_9)^I$,	from butane,	C_4H_{10}.	The Aldehyde Radicle,	$(CHO)^I$.
Amyl	$(C_5H_{11})^I$,	from pentane,	C_5H_{12}.		
Phenyl	$(C_6H_5)^I$,	from benzene,	C_6H_6.		

In considering the chemistry of the official organic substances, it is found convenient first to discuss the hydrocarbons themselves, and then the vast mass of derivatives, and in this work the order of the consideration of the latter will be based on a convenient standard of the number of carbon atoms they contain. In special books on organic chemistry it is usual to consider the derivatives of the hydrocarbons in groups, based on their structural characteristics; thus, all the fatty alcohols are considered together, likewise the fatty aldehydes and acids, but, from the pharmacist's point of view, it is better to discuss them in a different arrangement; namely, to study all the derivatives of ethane together, and then proceed to propane.

A convenient grouping of the derivatives is as follows:

The Halogen Derivatives.—In this case the hydrogen atoms are replaced by the halogen elements, chlorine, bromine, iodine. Thus, from CH_4 we can get CH_3Cl, CH_2Cl_2, $CHCl_3$, and CCl_4.

The first three of these can be expressed by the formulas:

$$R^{I}X,\ R^{II}X_2,\ \text{and}\ R^{III}X_3.$$

R standing for the radicle, X for the appropriate halogen element, the Roman numerals above R expressing the number of free bonds the same possesses.

Methane treated with bromine yields respectively—

$$CH_3Br,\ CH_2Br,\ CHBr_3,\ CBr_4,$$

and such is the case with iodine. Likewise, with ethane, one or even all the halogens can be replaced with chlorine, bromine, or iodine.

Of these halogen derivatives chloroform, bromoform, and iodoform are of pharmaceutic interest.

The Alcohols.—The formulas of these can be expressed by:

$$R^{I}OH,\ R^{III}(OH)_3,\ R^{VI}(OH)_6,\ \text{etc.}$$

Alcohols are substitution products of the hydrocarbons, in which one or more of the hydrogens are replaced by hydroxyl groups (OH). Official examples of this class are:

Ethyl alcohol	C_2H_5OH.
Glycerin	$C_3H_5(OH)_3$.
Mannitol	$C_6H_8(OH)_6$.

These alcohols are divided into primary, secondary, and tertiary alcohols, being classified according to their action under the influence of oxidation.

A *primary alcohol* oxidizes to an aldehyde and then to an acid; thus, ethyl alcohol, CH_3CH_2OH, on being treated with an oxidizing agent, yields first an aldehyde, CH_3CHO, and finally the acid, CH_3COOH.

A general formula of a primary alcohol shows as distinguishing characteristic the group RCH_2OH, that is, the carbon atom to which the hydroxyl is attached has also attached one radicle and two hydrogen atoms.

A *secondary alcohol*, on oxidation, does not yield an aldehyde and an acid, but yields a substance called a ketone.

Thus, secondary propyl alcohol, $CH_3CHOHCH_3$, yields on oxidation the ketone, acetone, CH_3COCH_3.

The rational formula of a secondary alcohol shows the characteristic grouping—

$$\genfrac{}{}{0pt}{}{R}{R}{>}CHOH.$$

In other words, connected with the carbon atom to which the hydroxyl is attached are found two radicles and only one hydrogen atom.

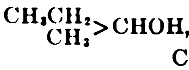
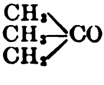
A tertiary alcohol is one which, on oxidation, yields neither an aldehyde nor a ketone, but breaks up under such treatment. The rational formula of tertiary alcohol can best be expressed as—

$$R_3COH;$$

in other words, to the carbon atom to which the hydroxyl is attached there are fastened three radicles and no hydrogen atoms at all.

Perhaps the differentiation in the three classes of alcohols can better be understood by a comparison of three such alcohols from the same hydrocarbon and the oxidation derivatives of each,

Thus, primary butyl alcohol, $CH_3CH_2CH_2CH_2OH$, yields on oxidation butyric aldehyde and butyric acid.

Secondary butyl alcohol,  $\genfrac{}{}{0pt}{}{CH_3CH_2}{CH_3}{>}CHOH$, under same treatment, yields methylethylketone, while tertiary butyl alcohol,  $\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}{>}COH$, breaks up into simpler compounds.

Another classification of alcohols is to call them monatomic, diatomic, and triatomic, etc., the Greek prefixes signifying the number of hydroxyls the alcohol possesses; thus glycerin, $C_3H_5(OH)_3$, is a triatomic alcohol.

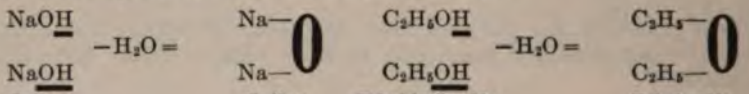
It will be seen that the characteristic radicle of alcohols is hydroxyl (OH). To express the same thing differently, alcohols are hydroxides of the organic radicles, just as the bases (p. 357) are inorganic hydroxides.

Thus, NaOH, sodium hydroxide, has an organic analogue in C_2H_5OH, ethyl hydroxide. Similar to $Ca(OH)_2$, calcium hydroxide, is $C_2H_4(OH)_2$, glycol, and as mate to $Fe(OH)_3$, ferric hydroxide, we have the organic hydroxide, $C_3H_5(OH)_3$, glycerin.

All three organic hydroxides cited above are classed among the alcohols. Those alcohols formed by adding hydroxyl to the benzene group of radicles (C_6H_5, C_6H_4, etc.) are called *phenols*, of which the type is ordinary phenol, carbolic acid, C_6H_5OH.

As alcohols represent organic hydroxides, so the class of *ethers* represent organic oxides. In a preceding chapter (p. 357) it was noted that sodium hydroxide, NaOH, was evolved from sodium oxide, Na_2O, by adding water thereto. Likewise, by taking water away from sodium hydroxide, sodium oxide is produced. In a somewhat analogous way, by removing water from ethyl hydroxide (alcohol), ethyl oxide (ether) is formed.

Let us compare the formation of the two:



$$\begin{array}{l} NaO\underline{H} \\ Na\underline{O}H \end{array} - H_2O = \begin{array}{l} Na- \\ Na- \end{array}\!\!\Big\rangle O \qquad \begin{array}{l} C_2H_5O\underline{H} \\ C_2H_5\underline{O}H \end{array} - H_2O = \begin{array}{l} C_2H_5- \\ C_2H_5- \end{array}\!\!\Big\rangle O$$

Sodium hydroxide. Sodium oxide. Ethyl hydroxide (alcohol). Ethyl oxide (ether).

The general formula of ethers can, therefore, be expressed as $R'OR'$.

Esters may be defined as salts of the alcohols.

We have seen the analogy between hydroxides and alcohols; between oxides and ethers; let us now show similarity between salts and esters. Suppose we take sodium hydroxide and add nitrous acid, we get water and sodium nitrite:

$$\begin{array}{rcccccccc} & NaOH & + & HNO_2 & = & H_2O & + & NaNO_2 \\ \text{Even so} & C_2H_5OH & + & HNO_2 & = & H_2O & + & C_2H_5NO_2 \\ & \text{Ethyl hydroxide.} & & \text{Nitrous acid.} & & & & \text{Ethyl nitrite.} \end{array}$$

An ester is the combination of a positive organic radicle with an acid radicle, just as a salt is a combination of a positive element with an acid radicle. The acid of the ester, just like the acid of the salt, can be either inorganic or organic, as is shown by the formulas of the official esters:

Ethyl nitrite	$C_2H_5NO_2$.
Ethyl acetate (acetic ether)	$C_2H_5C_2H_3O_2$.
Amyl nitrite	$C_5H_{11}NO_2$.
Phenyl salicylate (salol)	$C_6H_5C_7H_5O_3$.
Methyl salicylate	$CH_3C_7H_5O_3$.

Emphasis should be laid on the fact that esters are not in every respect similar to inorganic salts, a most striking difference being that while inorganic salts in solution dissociate into ions (p. 119), esters do not undergo ionic dissociation. Another point of difference is that, while the reaction occurring in the manufacture of salts usually runs in one direction, viz.,

$$NaOH + H_2SO_4 = Na_2SO_4 + H_2O,$$

the ester reaction is reversible, viz.,

$$(a)\ C_2H_5OH + HNO_2 = C_2H_5NO_2 + H_2O$$
$$(b)\ C_2H_5NO_2 + H_2O = C_2H_5OH + HNO_2.$$

The latter reaction, whereby esters are dissociated, is called the process of *saponification*.

Aldehydes.—This class of organic compounds has no analogues among the inorganic compounds, it being the product of the oxidation of a primary alcohol. An explanation of the same has just been given under the classification of the alcohols, and specific details will be left until we consider the official aldehydes; so here suffice it to say that the general formula of aldehyde is RCHO. An example of the official aldehydes is benzaldehyde, the chief constituent of oil of bitter almond.

Ketones.—As mentioned above, ketones are oxidation products of secondary alcohols, and their general formula is R_2CO. Thus, the secondary propyl alcohol, $CH_3CHOHCH_3$, under influence of oxidizing agents, loses the two hydrogen atoms, becoming CH_3COCH_3, the official acetone.

Acids.—The true organic acids are the oxidation products of primary alcohols or aldehydes, and their general formula is RCOOH, the group COOH being called *carboxyl*, as mentioned on p. 570.

As alcohols are monatomic, diatomic, and triatomic, according to the number of hydroxyls, so organic acids are monobasic, dibasic, and tribasic, according to the number of carboxyls they contain. Thus, acetic acid is an official example of the monobasic organic acid, while succinic acid, $C_2H_4(COOH)_2$, is an illustration of a dibasic acid.

Acids with alcohol radicles, that is, containing carboxyl and hydroxyl, are called *oxyacids*, and an official illustration is furnished in tartaric acid, which is a dibasic, diatomic oxyacid, as shown by the graphic formula. (See p. 615.)

In true acids only those hydrogen atoms in carboxyl groups are replaceable by a metal. This is why carbolic acid (C_6H_5OH) is not a true acid, but a phenol (p. 687).

Amines can be expressed by the general formulas—

$$RNH_2,\ R_2NH,\ \text{or}\ R_3N.$$

They can also be considered as ammonia in which one, two, or three hydrogens have been replaced by radicles. Thus we can obtain methylamine, CH_3NH_2, dimethylamine, $(CH_3)_2NH$, and trimethylamine, $(CH_3)_3N$.

The manufacture of these products is so simple and clear that it serves admirably for explaining their exact composition. Thus ammonia treated with methyl iodide gives the hydriodic acid salt of methylamine, and when the acid is removed by treating with potassa, methylamine remains.

Reaction: $(a)\ NH_3 + CH_3I = NH_2CH_3HI.$
$(b)\ NH_2CH_3HI + KOH = NH_2CH_3 + KI + H_2O.$

Methylamine, being treated with methyl iodide, will yield the hydriodic acid salt of dimethylamine, and this by treatment with potassa yields the free dimethylamine.

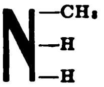
Reaction: $(a)\ NH_2CH_3 + CH_3I = NH(CH_3)_2HI.$
$(b)\ NH(CH_3)_2HI + KOH = NH(CH_3)_2 + KI + H_2O.$

Dimethylamine, being treated with methyl iodide, yields the hydriodic acid salt of trimethylamine, and the free base is obtained by treatment with potassa as above. Lastly, if trimethylamine is treated with methyl iodide, we get a very interesting body called tetramethylammonium iodide.

Reaction: $N(CH_3)_3 + CH_3I = N(CH_3)_4I.$

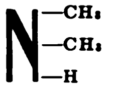
In the latter case the nitrogen shows the valence v, exactly as it does in the ammonium compounds. The similarity of these four bodies, the amines and the ammonium compounds respectively, is best shown by comparison of the four graphic formulas:

Methylamine.



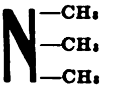
NH_2CH_3.

Dimethylamine.



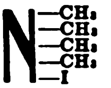
$NH(CH_3)_2$.

Trimethylamine.



$N(CH_3)_3$.

Tetramethyl ammonium iodide.



$N(CH_3)_4I$.

It might be added that for methyl can be substituted ethyl, propyl, or any other monovalent radicle. All the amines are quite similar to ammonia; the mono-amines have ammoniacal odor and all are decidedly basic.

The amines of the fatty series are of but little importance, but several of the aromatic series are of the utmost value; for example, aniline (p. 694).

CHAPTER XXXVI

HYDROCARBONS AND METHANE DERIVATIVES

THE FATTY SERIES OF HYDROCARBONS

This series of hydrocarbons, having the general formula C_nH_{2n+2}, are sometimes called the *aliphatic series*. As mentioned in the preceding chapter, representatives of these series are the homologues, methane, ethane, butane, pentane, hexane, etc., all similar and manufactured one from the other. Substances possessing the same general formula, but differing in relative number of atoms, are called *homologues.*

Manufacture.—That the members of this class can be made one from the other has already been mentioned; thus, methane, CH_4, can be converted into methyl iodide, (CH_3I), and methyl iodide, on treatment with metallic sodium, yields ethane by the following reaction:

$$2CH_3I + Na_2 = 2NaI + CH_3{-}CH_3 \text{ or } C_2H_6.$$

This is the usual way of making such hydrocarbons, although several other methods have been devised.

Chemical Behavior.—These hydrocarbons are saturated bodies; that is, they will absorb no more hydrogen nor will they combine with halogens except through the loss of hydrogen atoms. The halogen derivatives are formed as follows:

$$\begin{array}{lllllllll} CH_4 & + & Cl_2 & = & CH_3Cl & + & HCl. \\ CH_3Cl & + & Cl_2 & = & CH_2Cl_2 & + & HCl. \\ CH_2Cl_2 & + & Cl_2 & = & CHCl_3 & + & HCl. \\ CHCl_3 & + & Cl_2 & = & CCl_4 & + & HCl. \end{array}$$

Physical Properties.—The first of these series of hydrocarbons are gases. Hydrocarbons from C_6H_{14} are liquids, the first being quite volatile, the higher ones, that is, from $C_{14}H_{30}$, thick and stable liquids, while the higher hydrocarbons of the series, say from $C_{20}H_{42}$, are solid.

Considering the hydrocarbons as individuals, the first of the series, *methane*, CH_4, is commonly called *marsh-gas*, because formed by decaying vegetable matter, and thus it can be easily collected from the surfaces of some marshes. It is the chief constituent of natural gas. Methane is usually made by heating in a retort sodium acetate with sodium hydroxide, as shown in the following equation.

$$CH_3COONa + NaOH = CH_4 + Na_2CO_3.$$

It can also be prepared spontaneously by immersing zinc methyl in water, as shown in the following equation:

$$Zn(CH_3)_2 + H_2O = 2CH_4 + ZnO.$$

The zinc methyl used is made by heating together methyl iodide and zinc and distilling over the zinc methyl in the presence of absolutely dry hydrogen, the reaction being:

$$2CH_3I + Zn_2 = Zn(CH_3)_2 + ZnI_2.$$

Ethane C_2H_6, can be made as cited on p. 574, by treatment of methyl iodide with metallic sodium. It is usually made, however, by treating sodium propionate with sodium hydroxide in a manner similar to the method given for making methane from sodium acetate, the reaction being as follows:

$$CH_3CH_2COONa + NaOH = CH_3CH_3 + Na_2CO_3.$$

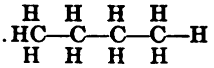
Propane, C_3H_8, is made by treating a mixture of methyl iodide and ethyl iodide with metallic sodium, the reaction being as follows:

$$CH_3I + C_2H_5I + Na_2 = 2NaI + CH_3—C_2H_5 \text{ (or } C_3H_8).$$

Butane, C_4H_{10}, is interesting, inasmuch as two substances of this formula—C_4H_{10}—are known. Already we have learned that where an element is found in three or four different forms, such forms are said to be allotropic (p. 380). On the other hand, where several compounds differ physically, but have the same chemical formula, they are called *isomeres*, and in organic chemistry a vast number of such isomeres are found, the two types of butane being the first example we meet. The two types of butane can best be described by submitting the graphic formula, and it will be found, on careful calculation, that these are the only two possible combinations of the formula C_4H_{10}.

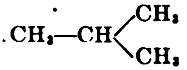
The two butanes:

Normal........................

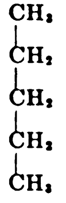


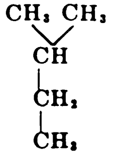
$$\begin{array}{ccccccccc} & \mathrm{H} & & \mathrm{H} & & \mathrm{H} & & \mathrm{H} & \\ \mathrm{H} & \mathrm{C} & — & \mathrm{C} & — & \mathrm{C} & — & \mathrm{C} & —\mathrm{H} \\ & \mathrm{H} & & \mathrm{H} & & \mathrm{H} & & \mathrm{H} & \end{array}$$

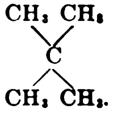
Isobutane......................



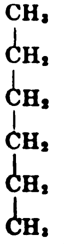
Pentane, C_5H_{12}, can occur in three different forms, namely:

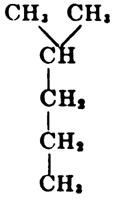


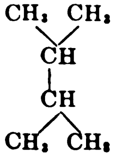


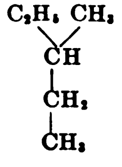


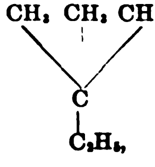
Hexane, C_6H_{14}, exists in five possible combinations, namely:











and all of these are known.

It will be seen from the above that the number of isomeres increases in proportion to the number of carbon atoms which the compound possesses, and in bodies containing a large number of carbon atoms the possible number of isomeres is enormous.

Of the hydrocarbons beyond hexane, such as C_7H_{14} and C_8H_{16}, nothing need be said beyond the fact that the formula of each can be worked out from the general formula C_nH_{2n+2}, as explained on p. 568.

The hydrocarbons above cited are of interest pharmaceutically because they are constituents of natural gas and of the petroleum products, and these we will now discuss.

Natural gas is chiefly methane combined with small quantities of ethane and oxygen. It is found in pockets beneath the surface of the earth, from which it is extracted by drilling, as in artesian wells, until the pocket is reached, when the gas rushes out and is piped to places where it is desired to be used. The city of Cleveland is furnished with natural gas brought from West Virginia, 120 miles away.

Petroleum is a thick, greasy liquid, obtained from pockets beneath the earth by drilling, as in the case of natural gas—in fact, the two are usually associated. The chief localities in which petroleum is obtained are Pennsylvania and the Central Western States (Ohio, Indiana, West Virginia), Texas, California, and in the neighborhood of Baku, South Russia.

Petroleum was first drilled for in Venango County, Pennsylvania, in 1859, although the oil which oozed from the earth was known by the Indians two hundred and fifty years ago. The Russian fields have been worked commercially only since the Pennsylvania fields have been operated, while the Texas fields were opened in 1900.

Petroleum is supposed to be the result of the decomposition of decaying fishy matter, the geological explanation of the limited areas where found being that in each case the pockets represent some sea that disappeared, these cataclysms of nature leaving the fishy denizens to be engulfed beneath masses of rock. Other theories are that vegetable matter under the influence of heat and pressure have decomposed to petroleum; while Moissan claimed that it was produced from inorganic material, that carbides were produced by the action of metals on carbon and that these combined with water under pressure to form the hydrocarbons of which petroleum is composed.

Of the petroleums, that of Pennsylvania and adjoining states is the best, the Russian containing sulphur, which must be removed from the distillate before it can be used for fuel or light, while the Texas petroleum contains a lesser amount of the lower boiling products and contains 1.4 to 1.8 per cent. sulphur. As mentioned above, the process of extracting petroleum from the earth is very simple, consisting merely of driving an artesian well, and when the bed-rock is reached, exploding the rocky layer with nitroglycerin. The depth of this rocky layer varies, some wells being 2600 feet deep.

When the free petroleum rushes through the tube to the earth's surface, it is with a pressure, more or less great, depending on the amount of gas mixed with petroleum. When first opened, in 1915, a "spouter" near Tampico, Mexico, attained the height of 600 feet.

At first the gas pressure is sufficient to cause a large flow of petroleum; in fact, in some cases the difficulty is properly to control the flow. After flowing a while, however, the pressure diminishes, until finally recourse must be had to pumps.

Petroleum, as it emerges from the earth, is a dark, greasy liquid of disagreeable odor. This forms "*stone oil*," which was formerly in considerable esteem medicinally as a liniment. Petroleum is pumped into tanks and purified from extraneous organic matter by treatment with sulphuric acid. The petroleum layer is then distilled, yielding:

1. Gases, such as methane, CH_4, and ethane, C_2H_6.
2. Rhigolene, chiefly C_5H_{12}, boiling-point, 10°C.
3. Gasoline (benzin), chiefly C_5H_{12} and C_6H_{14}, boiling-point 50°–60°C.
4. Insurance oil, coal oil, etc., C_7H_{16}, C_8H_{18}, etc., boiling-point, 60°–100°C.

5. Liquid petrolatum,	U.S.P.	Residue left after distillation of the more volatile portion. They are separated from each other by expression and distillation in vacuo.
6. Petrolatum,	U.S.P.	
7. White petrolatum,	U.S.P.	
8. Paraffin.	U.S.P.	

Rhigolene has been suggested (on account of its great volatility) as a local anesthetic, it freezing the surface on which it is sprayed. However, ethyl chloride is said to be better for this purpose.

Benzinum (U.S.P. VIII), or *petroleum ether*, is not the same as commercial benzin, which consists chiefly of higher boiling hydrocarbons. Even the phrase "petroleum ether" is not familiar to the average oil refiner, who calls the distillate approximating the official benzin, "88° naphtha." This phrase means a liquid has the specific gravity corresponding to "88 Baumé degrees light," which equals the specific gravity of the product desired.

The commercial samples examined by the writer, instead of distilling over at 50°C., as directed by the former pharmacopœia, did not begin to boil until 85°C. was reached, while practically all distilled over between 95°C and 100°C.

Benzin was directed by the last pharmacopœia as a solvent for India-rubber (when mixed with equal quantities of carbon disulphide), and was thus used in making mustard paper. Its value as a remover of grease-spots is well known.

BENZINUM PURIFICATUM—Purified Petroleum Benzin

(Benzin. Purif.—Petroleum Ether)

A purified distillate from American petroleum consisting of hydrocarbons, chiefly of the marsh-gas series. Preserve it carefully in well-closed containers, in a cool place remote from fire.

Summarized Description.

Colorless, non-fluorescent, volatile liquid, ethereal, or petroleum-like odor; highly inflammable; vapor mixed with air is explosive; insoluble in water; soluble in alcohol; miscible with ether, chloroform, benzene, volatile and fixed oils (except castor oil); sp. gr. 0.638 to 0.660; distils between 40° and 80°C.

For details see U.S.P., p. 75.

For *tests for identity*, for *impurities:* Other petroleum products (no greasy stain on paper). Pyrogenous products and sulphur compounds (no brown color with alcohol ammonia and silver nitrate). Benzene (no nitro-benzene odor when warmed with nitric and sulphuric acids) see U.S.P., p. 75.

Remarks.—This represents the crude petroleum ether free from other matter by oxidation with permanganate; the crude petroleum ether being shaken with an aqueous solution of potassium permanganate containing sulphuric acid and after separation from this fluid, it is shaken with an alkaline permanganate solution. It is directed for use by the present pharmacopœia as a solvent for the caoutchouc-like constituent of lactucarium in the manufacture of tincture of lactucarium. Also for the removal of the odorous principles of opium in making tincture of deodorized opium.

Gasoline in commerce is a term used synonymously with benzin, enormous quantities being now used as motive power in automobiling. The various illuminating oils, such as *insurance oil, coal-oil, kerosene* and *headlight oil* are petroleum products distilling over between 60° and 150°C. The higher the boiling-point, the safer is such an oil; as a matter of fact, the use of the lower boiling oils, such as benzin and gasoline, are dangerous, especially in wick lamps. As the last two are cheaper than the higher boiling oils, because more abundant, they are used to adulterate the higher boiling oils. To detect such adulteration has been devised the so-called "*flash test*," which consists in heating the sample in an appropriate apparatus and noting at what temperature the sample gives off inflammable vapors. Thus kerosene oil has a flash test of 45°C.; that is, its vapors should not ignite until the oil is heated to that temperature.

On the other hand the flash test of astral oil is about 150°C.

The first distillate of these bodies is always impure, and must be purified by treatment with sulphuric acid and redistillation.

The pharmaceutic products, *liquid petrolatum* and *petrolatum*, are obtained from the residue after distillation. This residue is distilled in vacuo, and according to its consistence forms hard or soft petrolatum, the latter having been introduced by Robert Chesebrough in 1871 under the name of "*vaseline.*" If, on the other hand, the purified residue is chilled and then expressed, the limpid oil flows out, forming *liquid petrolatum*, U.S.P., while the residue is the commercial *paraffin.* The purification in each case is accomplished by filtration through animal charcoal. *White petrolatum* is a specially purified form of petrolatum, preferably made from Russian petroleum.

PETROLATUM LIQUIDUM—Liquid Petrolatum

(Petrolat. Liq.—Liquid Paraffin—Mineral Oil)

A mixture of liquid hydrocarbons. Preserve it in well-closed containers, protected from light.

Summarized Description.

Two varieties. The *heavy* has sp. gr. 0.875 to 0.905; viscosity number, 3.1; the *light*, sp. gr. 0.830 to 0.870; viscosity number, 3. *Both*, are colorless oily liquids; little fluorescence; faint petroleum odor on heating; insoluble in water and alcohol; soluble in ether, chloroform, petroleum benzin and in fixed and volatile oils; dissolves camphor, menthol and thymol. For details see U.S.P., p. 314.

For *tests for identity*, for *impurities:* solid paraffins (remains clear on chilling). Acids (alcohol boiled with it, neutral to litmus). Carbonizable matter (does not darken mixture of sulphuric and nitric acid). Sulphur compounds (not darkened on heating with an alkaline solution of lead oxide and dehydrated alcohol) see U.S.P., p. 315.

Viscosity Test.—Based on speed of flow of the liquid from a 50-mil pipette. For details see U.S.P.

Remarks.—Liquid petrolatum is used for two purposes. It was originally introduced into medicine as a basis of atomizing fluids used in nose and throat troubles, in which antiseptics such as menthol, thymol, etc., were dissolved in the fluid. Of late years it has come into enormous use as a laxative. For the latter purpose a heavy liquid possessing considerable viscosity is required, whereas in atomizing a light fluid of low viscosity is indicated. The monograph of the present pharmacopœia provides for both kinds and also gives a viscosity test (see above) which is worthy of study.

The best type of heavy liquid petrolatum is known in commerce as Russian white oil or *liquid albolene.*

PETROLATUM—Petrolatum

(Petrolat.—Petrolatum Ointment—Petroleum Jelly)

A purified mixture of semi-solid hydrocarbons obtained from petroleum.

Summarized Description.

Unctuous mass; yellow to light amber; only slightly fluorescent; insoluble in water; almost insoluble in alcohol or in cold dehydrated alcohol; soluble in ether, chloroform, carbon disulphide, oil of turpentine, petroleum benzin, benzene and volatile and fixed oils; sp. gr. 0.820 to 0.865; melts between 38° and 54°C. For details see U.S.P., p. 314.

For *tests for identity*, for *impurities*: acids and alkalies (aqueous extract neutral to litmus). Fixed oils, fats or rosin (digested with alkaline solution and then made acid, no oil or fat separates) see U.S.P., p. 314.

Remarks.—Petrolatum is commonly known as petroleum jelly and appears in commerce under the trade names of *vaseline, cosmoline, saxoline*, etc.

PETROLATUM ALBUM—White Petrolatum

(Petrolat. Alb.—White Petroleum Jelly)

Petrolatum decolorized or nearly so.

Summarized Description.

White or faintly yellow unctuous mass; completely amorphous; transparent in thin layers after cooling. Otherwise like petrolatum. For details see U.S.P., p. 314.

Remarks.—White petrolatum represents a special form of solid petrolatum obtained from Russian petroleum. It was originally introduced in this country under the name of *albolene*. Since the European War, the Russian product has become very scarce in this country and fairly satisfactory American substitutes have been put upon the market. Most of these meet the requirements of the present pharmacopœia.

A cheap form of white petrolatum, made by dissolving paraffin in liquid petrolatum in varying quantities, has been put on the market. This, however, should never be used, as on standing it invariably becomes lumpy, due to separation of the paraffin.

These petroleum jellies are used as ointment bases, possessing over lard and other fats the great advantage of not turning rancid. Because of their greasy character, these jellies are usually grouped among the animal and vegetable fats, but from these the petroleum products differ entirely, the latter being the glycerin derivatives of oleic, stearic, and palmitic acids; their rancidity is due to their decomposition with liberation of the fatty acids just named. This is, of course, impossible with petrolatum, which is a mixture of the hydrocarbons, and, like all hydrocarbons, are not easily decomposed, even by chemicals. In fact, the halogens are about the only substances which will combine directly with the hydrocarbons.

This chemical stability is of great advantage in so far as the absence of rancidity is concerned, but, on the other hand, in making ointments, its stability is in some cases disadvantageous. Thus, physicians sometimes prescribe alkalis with fats, with the intention of securing a form of soap. If, instead of the animal or vegetable fat, the physician prescribes a petrolatum product, the same results are not obtained and an unsightly mixture occurs. An example of this is found in prescriptions (p. 952).

Another drawback to the use of petroleum jelly as an ointment base is the fact that it is by no means as easily absorbed by the skin as are the animal or vegetable fats.

Petrox Preparations.—Ointment bases consisting of petrolatum emulsified with a soap made from ammonia and oleic acid now enjoy considerable popularity. These are described on pp. 267 and 337.

PARAFFINUM—Paraffin

(Paraff.)

A purified mixture of solid hydrocarbons usually obtained from petroleum.

Summarized Description.

Colorless or white, more or less translucent masses; deposits crystalline from solutions; insoluble in water or alcohol, slightly soluble in dehydrated alcohol; soluble in the solvents mentioned under petrolatum; sp. gr. 0.900; melts between 50° and 57°C.; ignites on strong heat, depositing carbon; not affected by cold concentrated sulphuric or nitric acid. For details see U.S.P., p. 309.

For *tests for identity*, for *impurities:* acids (hot alcoholic extract does redden litmus paper) see U.S.P., p. 310.

Remarks.—Paraffin consists of the hydrocarbons from $C_{24}H_{50}$ to $C_{27}H_{56}$, or possibly four times the formula just given. It has of late come into extensive use for such purposes as making wax-paper, candles, and for the polishing of floors and other wood.

Like the liquid and soft petrolatums, it is practically impervious to ordinary chemicals. It can even be boiled with concentrated sulphuric acid without any change in its properties, this test being employed in examining beeswax to see if adulterated with paraffin (p. 669).

Ceresin is a purified form of *ozokerite*, a paraffin-like substance mined in Galicia.

Ichthyol, (N.N.R.), or *ammonium ichthyol sulphonate*, is a product obtained by the distillation of "asphalt stone" a bituminous shale, found in Tyrol. The distillate is sulphonated by treatment with concentrated sulphuric acid, and is then converted into the ammonium compound. Commercial ichthyol is an aqueous solution of the above compound and contains about 50 per cent. of a mixture of ammonium ichthyol sulphonate and of ammonium sulphate. It contains about 19 per cent. of sulphur. It is used largely in the treatment of skin diseases, both internally and externally. *Dose.*—3 to 30 minims.

The compounds of methane of pharmaceutic interest are:

Methyl chloride	CH_3Cl.
Chloroform, U.S.P	$CHCl_3$.
Bromoform, U.S.P	$CHBr_3$.
Iodoform, U.S.P	CHI_3.
Methyl alcohol	CH_3OH.
Formic acid, N.F.	$HCOOH$.
Formaldehyde	$HCHO$.
Solution of formaldehyde, U.S.P., contains 37 per cent.	$HCHO$.
Paraformaldehyde, U.S.P.	$(HCHO)_3$.
Methyl salicylate, U.S.P	$CH_3C_7H_5O_3$.

Methyl Chloride (CH_3Cl).—This is made by treating methyl alcohol with hydrochloric acid in the presence of zinc chloride (Grove's method), the zinc chloride being used as a dehydrator—that is, to remove the water. It is now produced commercially from *schlemp*, or the refuse in the beet sugar manufacture. Methyl chloride is a colorless gas, and is put upon the market in liquid form which boils at 22°C., made by compressing the gas, and is used as a solvent in perfumery and in synthesis of dye-stuffs. Its medicinal use is for the purpose of producing local anesthesia, by directing it in a stream upon the part desired to become benumbed, as was the case in rhigolene.

CHLOROFORMUM—Chloroform

(Chlorof.)

A liquid consisting of not less than 99 per cent. nor more than 99.4 per cent., by weight, of $CHCl_3$ (119.39), and not less than 0.6 per cent. nor more than 1 per cent. of alcohol. Preserve it in well-stoppered bottles; in a cool place, protected from light. Caution: Care should be used in vaporizing Chloroform in the presence of a naked flame, as noxious gases are produced.

Summarized Description.

Clear, colorless mobile liquid; characteristic ethereal odor; burning sweet taste; soluble in 210 times its volume of water; miscible with alcohol, ether, benzene, petroleum benzin and with volatile and fixed oils; sp. gr. 1.474 to 1.478; volatilizes at low temperatures; boils at 61°C.; not inflammable but its heated vapor burns with a green flame. For details see U.S.P., p. 108.

For *tests for identity*, for *impurities:* chlorides (cold aqueous extract not affected by silver nitrate). Free chlorine (aqueous extract not colored blue with potassium iodide and starch paste). Impurities decomposable by sulphuric acid (does not color that acid when shaken with it in a cylinder). Odorous decomposition products (the acid from above test diluted with water has but little odor). Chlorinated decomposition products (the diluted fluid just mention is not affected by silver nitrate). For details see U.S.P., p. 109.

Remarks.—Chloroform was discovered by Dr. Guthrie, of Jewettsville, N. Y., in 1831, and was considered merely as an interesting chemical specimen until after the discovery of anesthesia by Long in 1842, and the popularizing of the discovery by Wells (1844) and Morton (1846) when it was discovered what chloroform could be used for that purpose as well as could ether, and since that time it has been of untold benefit in alleviating suffering attendant upon surgical operations.

Chloroform is made by treating alcohol with chlorinated lime. Chlorinated lime is, as learned on p. 375, a loose combination of chlorine and the alkali, lime; chlorine acting on alcohol gives chloral, as will be learned on p. 599, and chloral in contact with an alkali gives chloroform.

As this method of manufacture is so similar to that of chloral, full explanation of the process had best be left until we consider that chemical. The same applies to the manufacture of a very pure chloroform by treatment of chloral with an alkali.

Of recent years a large amount of chloroform has been produced by the so-called acetone process, patented by Michaelis, in which acetone is treated with chlorinated lime in the same way as in the alcohol process, the advantage of the acetone process over the alcohol process being that the yield is very good, about 200 per cent., and the product much purer than that yielded by the alcohol process. Equation showing the acetone process is as follows:

$$2(CH_3)_2CO + 3Ca(OCl)_2 = 2CHCl_3 + 2Ca(OH)_2 + Ca(C_2H_3O_2)_2.$$

The chloroform for anesthesia is always purified by treatment with sulphuric acid and redistillation.

Another method of obtaining absolutely pure chloroform is that of Pictet. Chloroform solidifies at -80°C., whereas all the other impurities are solidified at -70°C. There fore, the mixture is subjected to a temperature of -70°C., and the still liquid chloroform poured off from the frozen impurities. It is also made electrolytically.

A very delicate test for chloroform is the so-called *isonitrile reaction*, this consisting of treating the chloroformic liquid with an amino-compound (for example, aniline) in the presence of an alkali, when the disgusting odor of the poisonous gas, phenyl (or some other) isonitrile (C_6H_5NC) is evolved. This test is interesting as being equally valuable for identifying the amines, any of which can be employed in place of aniline. The equation showing the reaction is as follows:

$$C_6H_5NH_2 + CHCl_3 + 3KOH = C_6H_5NC + 3KCl + 3H_2O.$$

It will be noticed that the pharmacopœia permits the presence of 1 per cent. of alcohol, this being added to preserve same, it being found that pure chloroform decomposes. The fact that chloroform does undergo decomposition renders it necessary for the pharmacist to assure himself that the chloroform he dispenses for anesthesia is strictly pharmacopœial, for should a death result during anesthesia, one of the first things done by the physician is to investigate the purity of the chloroform, and if found impure, it will prove very disastrous to the reputation of the pharmacist dispensing same. Hence every sample of chloroform should be carefully tested according to the pharmacopœia for chlorinated products and for empyreuma.

A very simple and satisfactory test for empyreuma is the sulphuric acid test: when a layer of chloroform is poured upon pure sulphuric acid, no coloration should take place at point of contact. A simple test for acidity in chloroform is the fact that pure chloroform does not attack a cork of a container. If, therefore, the cork softens or becomes yellow, it is a sure indication of the presence of acid. Of course, the accurate test for acidity is by the use of litmus-paper.

Chloroform allowed to vaporize in the presence of artificial light or heat becomes oxidized, the reaction being:

$$CHCl_3 + \underset{\left(\substack{\text{From}\\ \text{air}}\right)}{O} = HCl + \underset{\text{(Phosgene)}}{COCl_2}.$$

Nicloux, on the other hand, thinks that the decomposition of chloroform by action of light and air produces carbon monoxide. Be that as it may, it is a dictum in surgery, that chloroform should not be used as an anesthetic in cases where gas light is employed.

Besides this employment, as an anesthetic by inhalation, chloroform is used internally as a sedative and externally as a rubefacient.

The official preparations of chloroform are the water (p. 176), the liniment (p. 266) and the spirit (p. 181).

Dose.—3 decimils (5 minims).

BROMOFORMUM—Bromoform

(Bromof.)

A liquid consisting of about 96 per cent., by weight, of $CHBr_3$ (252.77) and about 4 per cent. of dehydrated alcohol. Preserve it in glass-stoppered bottles, in a cool place, protected from light.

Summarized Description.

Heavy, transparent, colorless mobile liquid; ethereal odor; sweet chloroform-like taste; sp. gr. 2.595; slightly volatile at ordinary temperatures; not inflammable as liquid but vapors are; leaves not more than 0.06 of 1 per cent. residue. For details see U.S.P., p. 84.

For *tests for identity*, for *impurities:* Free acid (aqueous extract neutral to litmus). Bromides and brominated compounds (aqueous extract not made opalescent by silver nitrate). Free bromine (aqueous extract does not affect potassium iodide and starch paste). Acetone (aqueous extract treated with ammonia water, iodine and ammonium iodide does not yield iodoform) see U.S.P., p. 84.

Remarks.—This official is made by treating alcohol or acetone with bromine in the presence of an alkali and distilling the bromoform resulting from the reacting liquid. Bromoform is recommended as a sedative, particularly in whooping-cough, although its use for this purpose is not devoid of danger.

Dose.—2 decimils (3 minims).

IODOFORMUM—Iodoform

(Iodof.)

Triiodomethane [CHI_3 = 393.77] usually obtained by the action of iodine upon alcohol or acetone, in the presence of an alkali or alkali carbonate. Preserve it in well-closed containers, in a cool place, protected from light.

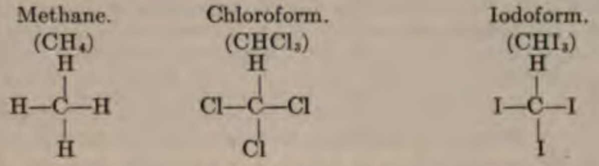
Summarized Description.

Fine lemon-yellow powder or hexagonal crystals; peculiar persistent odor; unpleasant sweetish taste; almost insoluble in water; soluble in about 48 parts of alcohol, in about 100 parts of glycerin, in about 15 parts of chloroform and in about 5.4 parts of ether; also soluble in carbon disulphide and olive oil; melts at 115°C. and volatilizes at higher temperatures. For details see U.S.P., p. 228.

For *tests for identity*, for *impurities:* (ash, not more than 0.2 of 1 per cent.). Moisture (not more than 1 per cent.). Soluble coloring matter and picric acid (aqueous extract colorless and not bitter.) Acids and alkalies (aqueous extract neutral to litmus) see U.S.P., p. 228.

Remarks.—Iodoform is a product chemically very similar to chloroform.

Chloroform is trichlormethane; iodoform is tri-iodomethane. A graphic comparison may be useful:



Methane.	Chloroform.	Iodoform.
(CH_4)	($CHCl_3$)	(CHI_3)
$H-\overset{\overset{H}{\vert}}{\underset{\underset{H}{\vert}}{C}}-H$	$Cl-\overset{\overset{H}{\vert}}{\underset{\underset{Cl}{\vert}}{C}}-Cl$	$I-\overset{\overset{H}{\vert}}{\underset{\underset{I}{\vert}}{C}}-I$

Iodoform is made by treating alcohol with the iodine in the presence of an alkali, the reaction being as follows:

(Alcohol).		Iodine.		Iodal.		Hydriodic acid.
C_2H_5OH	+	I_8	=	CI_3CHO	+	5HI.

Iodal.		Potassium hydroxide.		Iodoform.		Potassium formate.
CI_3CHO	+	KOH	=	CHI_3	+	HCOOK.

It will be seen in the above reaction that only three of the eight atoms of iodine employed are converted into iodoform, the other five forming hydriodic acid. In view of the high cost of iodine such waste cannot be permitted, and, therefore, chlorine is passed through the reacting liquid, with the formation of HCl and liberation of iodine, the five atoms of which are in time converted into iodoform. In practice, potassium bicarbonate is the alkali employed in the above reaction. Iodoform is now largely made by electrolytic methods.

The manufacture of iodoform, by the way, affords an excellent test for alcohol, even when present in minute proportions. To the alcoholic liquid is added a grain or so of iodine and a few drops of solution of potassa, and the mixture is gently warmed. If there settles out a yellow precipitate of the characteristic iodoform odor, the liquid contains alcohol.

Iodoform, which was discovered by Serullas in 1822, is one of the most valuable antiseptics, the sole objection to its use being its very disagreeable odor. Many efforts are noted in pharmaceutic journals for masking this odor, but none have proved satisfactory, about the most successful masker being coumarin. *Aromatized iodoform* (N.F.) is a preparation of this character.

The antiseptic properties of iodoform being due to iodine, several odorless iodine preparations have been put on the market as substitutes for iodoform. The most popular of these iodoform substitutes are *iodol* (p. 682) and *aristol* (p. 724), and neither of these can approach iodoform in actual percentage of iodine. Iodoform contains 96 per cent. of iodine, as an estimation of the molecular weight will show, while iodol contains 84 per cent. and aristol contains 46 per cent.

Dose.—250 milligrammes (4 grains).

Carbon Tetrachloride, CCl_4, has come into considerable use during the past decade. It is made by passing the vapor of carbon disulphide over carbon heated in an electric furnace or by the chlorination of chloroform, iodine being employed as a catalytic agent. It is a volatile liquid having the specific gravity 1.6084 at 9.5°C. and its vapor is poisonous. It is used as a fire extinguisher, and as an ingredient for making benzin non-inflammable. Its use in cleansing the hair should be prohibited, as death has resulted from its employment in that manner.

Methyl alcohol (CH_3OH) was obtained by Robert Boyle in 1661 as a product in the destructive distillation of wood. By reason of its source its common name is *wood alcohol,* while a purer form of wood alcohol has been put on the market under the trade name of *Columbian methanol.*

Of theoretic interest is the manufacture of wood alcohol from methyl salicylate or oil of wintergreen, this product being treated with sodium hydroxide, yielding sodium salicylate and methyl hydroxide or wood alcohol (p. 710).

The commercial manufacture, however, is by the destructive distillation of wood. Wood cut into billets, placed in iron retorts, and heated, yields, besides gases, a tarry liquid called wood vinegar, or crude *pyroligneous acid,* which consists of a mixture of methyl alcohol, acetone, acetic acid, and a large number of other products.

To the crude distillate, lime is added and the methyl alcohol and acetone are separated from the calcium acetate, thus formed, by a second distillation. The methyl alcohol and the acetone are then separated from each other by careful fractional distillation, although sometimes chemicals, such as calcium chloride are used to accomplish the separation.

While wood alcohol is a useful solvent, its toxic properties and its tendency to produce blindness, even when applied externally has resulted in the prohibition of its use in medicinal and toilet preparations.

Methyl ether $(CH_3)_2O$, is unofficial, and is mentioned only as the first representative of the class of ethers regarding which full explanation will be given when considering the official ether (p. 592).

Methyl ether is made by treating wood alcohol with sulphuric acid, and is quite popular in certain sections of Ireland as a tipple.

Methyl Salicylate.—This is the first representative of the official esters, and is official in three forms: (*a*) The synthetic methyl salicylate; (*b*) oil of wintergreen; and (*c*) oil of sweet birch, the two last mentioned being natural products, consisting chiefly of the chemical above mentioned. It is more convenient, however, to consider this substance under the head of salicylic acid, hence it is deferred until that time (p. 709).

Formaldehyde (HCHO).—This, like all other aldehydes, is produced by the oxidation of the corresponding alcohol, which in this case is methyl alcohol; the reaction can be more clearly expressed as follows:

$$HCH_2OH + O = H_2O + HCHO.$$

The usual method of manufacture of aldehydes from alcohol is by the oxidation with potassium dichromate and sulphuric acid, but in the case of formaldehyde oxidation by chemical means usually does not stop at formaldehyde, but is apt to produce formic acid or even to split into carbon dioxide and water; hence the oxidation of wood alcohol into formaldehyde is best accomplished without the aid of chemicals, and is usually performed by the incomplete combustion of methyl alcohol. If gaseous formaldehyde is desired, this combustion is accomplished by burning the formaldehyde from a wick and covering the flame with a cone of platinum wire. Such is the principle of most of the formaldehyde lamps now largely used for purposes of disinfection. The same results can be obtained by heating wood alcohol in a flask, and as the vapor begins to rise, immersing therein a red-hot platinum spiral. The commercial method of manufacture of the chemical is by passing the vapors of wood alcohol through heated tubes containing platinum or copper spirals.

Formaldehyde is a gas of very peculiar pungent odor, and is placed on the market in aqueous solution, the commercial *formalin* being a 37 per cent. (saturated) solution of same. This is now official as *liquor formaldehydi.*

Formaldehyde is a valuable antiseptic, hence the use of formaldehyde in lamps for the disinfecting of rooms and in solution as a food preservative. The latter use of formaldehyde is prohibited, inasmuch as experiments have shown that formaldehyde, even in minute traces, injures digestion.

Formaldehyde forms with gelatinous substances insoluble compounds, and for this purpose is employed in solidifying glycerin jelly for microscopic mounts, and since hide is largely gelatin, formaldehyde can be employed for converting same into leather. The tests for formaldehyde are important in food analyses and in the examination of grain alcohol. Hehner's test is based on the violet color produced when minute quantities of ferric chloride, protein and formaldehyde are mixed, while in Leach's method of detecting formaldehyde in milk, hydrochloric acid containing some ferric chloride is added to the sample, which is then warmed, when a violet color indicates formaldehyde. Like all aldehydes and ketones, a formaldehyde solution restores the color of a fuchsin solution that has been bleached with sulphurous acid. This fact is made use of in the official test for wood alcohol in grain alcohol. (See p. 591.)

From formaldehyde many interesting syntheses have been made, the most striking of which was the condensing of same under treatment of calcium hydroxide into formose or acrose, a variety of sugar having the formula of $C_6H_{12}O_6$. This was accomplished by Lowe (1886), and gives an inkling of that wonderful method whereby plants, by the absorption of carbon dioxide from the air, grow from a seed to the large and lusty organism, the tree.

The entire details of the process are not yet fully understood, but it is generally accepted to-day that the conversion of carbon dioxide into other carbon compounds is accomplished chiefly by the intermediate product, formaldehyde.

Plants absorb carbon dioxide and water, and in these two bodies, CO_2 and H_2O, we have the elements that will form HCHO. As yet this synthesis, this building up, has not been artificially accomplished, nature holding the secret to herself. The next step in the process has been accomplished in Loew's synthesis. Formaldehyde is CH_2O. If CH_2O is multiplied by six, the result is $C_6H_{12}O_6$. Theoretically, it seems simple to convert glucose, $C_6H_{12}O_6$, into sugar, $C_{12}H_{22}O_{11}$, as explained on p. 623, and likewise to convert sugar into starch, $C_6H_{10}O_5$, and into cellulose, which has the same proportional formula and which is the main constituent of woody tissue.

The conversions have not been practically accomplished, but it can be comprehended as plausible, since the reverse operation has been done. Cotton or starch treated with sulphuric acid will yield glucose.

To sum up the process by which plants grow:

H_2O and CO_2 should give HCHO formaldehyde.
6HCHO does give $C_6H_{12}O_6$, acrose, a form of glucose.
$C_{12}H_{24}O_{12}(2C_6H_{12}O_6—H_2O)$ should give $C_{12}H_{22}O_{11}$ sugar.
$C_{12}H_{22}O_{11}—H_2O$ should give $C_{12}H_{20}O_{10}$ or $2C_6H_{11}O_5$.
$(C_6H_{10}O_5)$ is the formula of starch and cellulose.

Strassburger, after extensive microscopic and chemical work, decides that the method of starch formation in plants is not as simple as here outlined. He claims that very intricate intermediate products result, which is very likely, as nature rarely performs the synthesis in a direct manner. The above explanations are, therefore, merely approximate, their aim being to impress the wonderful manner in which plants live and increase on nutriment drawn almost exclusively from the air.

LIQUOR FORMALDEHYDI—Solution of Formaldehyde

(Liq. Formaldehyd.)

An aqueous solution containing not less than 37 per cent. by weight of CH_2O or H.COH (30.02) with varying amounts of methyl alcohol to prevent polymerization. Preserve it in a moderately warm place, protected from light.

Summarized Description.

Clear colorless liquid; pungent odor; caustic and irritating; miscible with alcohol and water; in cold and on standing becomes turbid (paraformaldehyde precipitates). For details see U.S.P., p. 245.

For *tests for identity*, for *impurities;* free acids (not more than 1 mil n KOH required to neutralize 20 mils) and for *assay* see U.S.P., p. 245.

Remarks.—In view of the full statements as to formaldehyde given on the preceding page, further comments are not necessary.

PARAFORMALDEHYDUM—Paraformaldehyde

(**Paraform.**—Paraform—Trioxymethylene)

It contains not less than 95 per cent. of $(HCHO)_3$ (90.05), a polymeric form of formaldehyde. Preserve it in well-closed containers in a cool place, protected from light.

Summarized Description.

White friable masses or powder; slight formaldehyde odor; on heating, some goes into formaldehyde and some sublimes; soluble in water and in fixed alkali solutions; insoluble in alcohol or ether. For details see U.S.P., p. 310.

For *tests for identity* and for *assay* see U.S.P., 310 and also Part V of this book.

Remarks.—This polymer of formaldehyde represents 3 molecules of HCHO condensed into one molecule. The condensation can be accomplished by the simple expedient of cautiously evaporating the official solution of formaldehyde.

Paraformaldehyde or *trioxymethylene* is a white crystalline powder, that is used as an antiseptic and escharotic.

Dose.—500 milligrammes (8 grains).

Methylal $HCH(OCH_3)_2$.—This substance is made by oxidizing wood alcohol with manganese dioxide and sulphuric acid and distilling the mixture. It is used as a hypnotic in doses of one to two grammes.

Acidum Formicum (N.F.) or *formic acid*, HCOOH, was discovered by Fischer and Ray in 1670, they finding same in the distillate from red ants (*Formica rufa*), hence the name. Some claim to know that the irritating substance in the hairs of the stinging nettle, *Urtica dioica*, is chiefly formic acid, while others think that it is an enzyme.

Potassium cyanide on being cooked yields potassium formate. This, however, is not the commercial method of manufacture, and is merely suggested as a warning that pharmacists should never use heat in preparing solutions of potassium cyanide. While formic acid can be made by oxidation of methyl alcohol, it is usually prepared by heating oxalic acid with glycerin, the distillate being practically pure formic acid.

Formic acid has very little medicinal and pharmaceutic use but its salts, the formates are now in considerable use. It is interesting to note that it is a reducing agent, being capable of producing the separation of metallic silver from the solution of silver nitrate. It is the only acid of the series possessing reducing power.

Formamide, $HCONH_2$, produced by the condensation of formic acid with ammonia, is the basis of several synthetic medicines. (See p. 600.)

The Methylamines—Of these, the only one of pharmaceutic value is *trimethylamine*, $(CH_3)_3N$. This body was introduced into the market under the name of *propylamine*, it being an isomere of that body which has the formula $C_3H_7NH_2$. It is found in small traces in arnica root, and a considerable quantity of the brine used for pickling herring. Its commercial source is beet sugar residues, and it had considerable vogue for rheumatism, but its disagreeable taste prevented its general use. Dose, 2 to 4 drops.

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CHAPTER XXXVII

ETHANE DERIVATIVES

THE derivatives of ethane of pharmaceutic value are:

Ethyl chloride, U.S.P.	C_2H_5Cl.
Alcohol, U.S.P.	C_2H_5OH.
Ether, U.S.P.	$(C_2H_5)_2O$.
Ethyl sulphate	$(C_2H_5)_2SO_4$.
Ethyl nitrite	$C_2H_5NO_2$.

(in spirit of nitrous ether, U.S.P.).

Ethyl acetate,	$C_2H_5C_2H_3O_2$.
Ethyl carbonate, U.S.P.	$C_2H_5NH_2CO_2$.

(described among the urea derivatives).

Aldehyde	CH_3CHO.
Paraldehyde, U.S.P.	$(CH_3CHO)_3$.
Chloral hydrate, U.S.P.	$CCl_3CHO + H_2O$.
Chloral formamide	$CCl_3CH(OH)(NHCOH)$.
Acetic acid, U.S.P.	CH_3COOH.
Sodium cacodylate, U.S.P.	$Na(CH_3)_2AsO_2$
Trichloracetic acid, U.S.P.	CCl_3COOH
Oxalic acid	$(COOH)_2$.

ÆTHYLIS CHLORIDUM—Ethyl Chloride

(Æthyl. Chlor.)

Monochlorethane [C_2H_5Cl or $CH_3CH_2Cl = 64.50$]. Preserve it in hermetically sealed containers, in a cool place, remote from fire, and protected from light.

Summarized Description.

Colorless mobile very volatile liquid at low temperatures or under pressure; boils between 12° and 13°C.; vapor very inflammable; burns with a smoky greenish flame producing hydrogen chloride. For details see U.S.P., p. 34.

For *tests for identity*, for *impurities:* hydrochloric acid (alcohol solution not made turbid on adding silver nitrate). Alcohol (aqueous extract not oxidized to aldehyde by potassium dichromate and sulphuric acid) see U.S.P., p. 34.

Remarks.—Ethyl chloride is made by treating alcohol with hydrochloric acid gas. It can also be made, as already explained, as all other halogen derivatives of the hydrocarbons, by treatment of the appropriate hydrocarbon (in this case, ethane) with the proper halogen (in this case, chlorine).

Ethyl chloride is so volatile that it can be kept in its liquid form only when under heavy pressure in sealed tubes. Note that the vapor is inflammable and must be kept away from a flame. It is used, under such trade names as *kelene*, as a local anesthetic (as described under Rhigolene, p. 577), and is now being employed either by itself or in combination with chloroform or ether as a general anesthetic.

Dichlor-ethylene, $C_2H_2Cl_2$ and other chlorinated compounds of ethane and ethylene, such as C_2HCl_3, C_2Cl_4, $C_2H_2Cl_4$ and C_2HCl_5 are now in considerable use as non-inflammable, non-explosive solvents. Dichlor-ethylene has been recommended as a solvent for iodine; "I.D.E." being a 2.48 per cent. solution of iodine in that solvent.

Ethyl hydroxide (C_2H_5OH) has been known from the earliest times in the form of alcoholic liquids, one of the first references being the well-known story of Noah and his vineyard.

The isolation was first performed by Rhazes (tenth century), and the name alcohol was first applied in the thirteenth century, the name being of Arabic origin.

Passing over the several syntheses of alcohol, it may be said that most commercial alcohol is made by the fermentation of substances containing starch or sugar. If dilute watery preparations of starch and sugar are allowed to stand, the spores of the yeast plant, *Saccharomyces cerevisiæ*, present in the air, locate in same and begin to grow, the process of the plant's assimilation producing in saccharine liquid the chemical change called *fermentation*. It was formerly considered that the chemical change could be induced only by the actual process of plant life, but it is now known that the fermentation is entirely due to the chemical action of the protoplasm of yeast. The reaction of the fermentation expressed in simplest form is as follows:

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2,$$

but the real process is far more complicated, as is evidenced by the large number of side-products of fermentation, such as glycerin, succinic acid, and amylic alcohol, invariably found in the fermented liquid. In order to obtain alcohol it is necessary to subject the fermented liquid (usually called the *mash*) to distillation. Of late years, alcohol has been made from sawdust, by converting the cellulose thereof into glucose by action of sulphurous acid under pressure and subsequent fermentation of the glucose thus produced.

Wines are made by the fermentation of the juice of grapes and eventual clarification of the same. **Vinum Album** (U.S.P. VIII) or *white wine* is made by fermenting the juice of the grape, freed from the skins; while **Vinum Rubrum** (U.S.P. VIII) or *red wine* is obtained by the fermentation of the juice of the red grapes in the presence of the skins.

Champagne deserves passing comment. This represents white wine containing from 8 to 9 per cent. of alcohol, which is carbonated with carbon dioxide generated during the process of fermentation. The sweetened wine with a minute quantity of yeast is placed in tightly stoppered bottles, which are inverted on a rack and left in a room, the temperature of which favors fermentation. When the fermentation has reached the proper stage—which is determined by experience—the wine is left to cool for several months, during which time the sediment collects in the neck of the bottle while the gas collects at the inverted bottom. When completely settled, an expert workman passes from bottle to bottle, drawing out the corks for a period long enough to remove the sediment without serious loss of the other contents. The product is then corked securely and sent to market. It can readily be seen that the operation of removing the sediment is exceedingly delicate, and can be accomplished only by failure to produce this result on a large number of bottles. This loss plus the loss of breakage of bottles during process of fermentation gives the real reason for the high cost of champagne.

Beer.—This is the product of the fermentation of malt, hops being added to give the product a characteristic taste. The ordinary lager beer contains 3 to 4 per cent. of alcohol; the dark, heavy Munich beer contains 8 per cent. of alcohol, while the so-called Berlin or Weiss beer contains only 2 per cent., which amount is too small to effect complete preservation of the product, hence it must be fresh when dispensed.

Spiritus Frumenti (U.S.P. VIII) or *whisky* is a product of distillation of the mash of fermented grain, usually of a mixture of corn, wheat, and rye, and at least four years old. Whisky contains from 37 to 47.5 per cent. of alcohol by weight. It should be four years old, because some of the side-products (fusel oil, for example) are deleterious, but on aging four years this fusel oil will have combined with the other constituents of whisky to produce an aromatic substance which in itself is practically harmless.

Spiritus Vini Gallici (U.S.P. VIII) or *brandy* is obtained by the distillation of the fermented, unmodified juice of fresh grapes, and at least four years old. It should contain 39 to 47 per cent. by weight, of alcohol, and should be four years old.

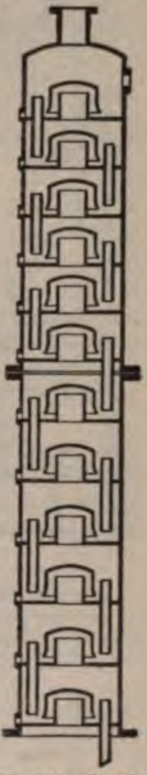


Fig. 234.—Rectifying column. Longitudinal section.

The deletion of whisky and brandy from the present pharmacopœia caused considerable controversy. Their rejection, based upon the difficulty of devising acceptable tests for purity, became the subject of discussion by the public press and by temperance advocates.

Alcohol is obtained by the redistillation of whisky, the fusel oil, glycerin, and other extraneous matter being separated from same by the process called *dephlegmation.* This long word had been bequeathed us by the alchemists, whose favorite treatment of a substance was to submit it to distillation. If a portion thereof was volatile, the same was called *spirit,* while the less volatile portion which was left behind was called *phlegm.* To produce this spirit (alcohol) it was necessary to remove same from the phlegm and the process was called dephlegmation. This is accomplished by heating the whisky in an appropriate still body, and making the vapors rise through a tall tower or column before diverting same into the condensing worm. This tower or column apparatus is generally provided with a series of projections, which condense the less volatile portions, permitting the passage only of the pure alcohol. A glass dephlegmator for smaller operations of the laboratory is shown in Fig. 236. Alcohol is official in three different forms.

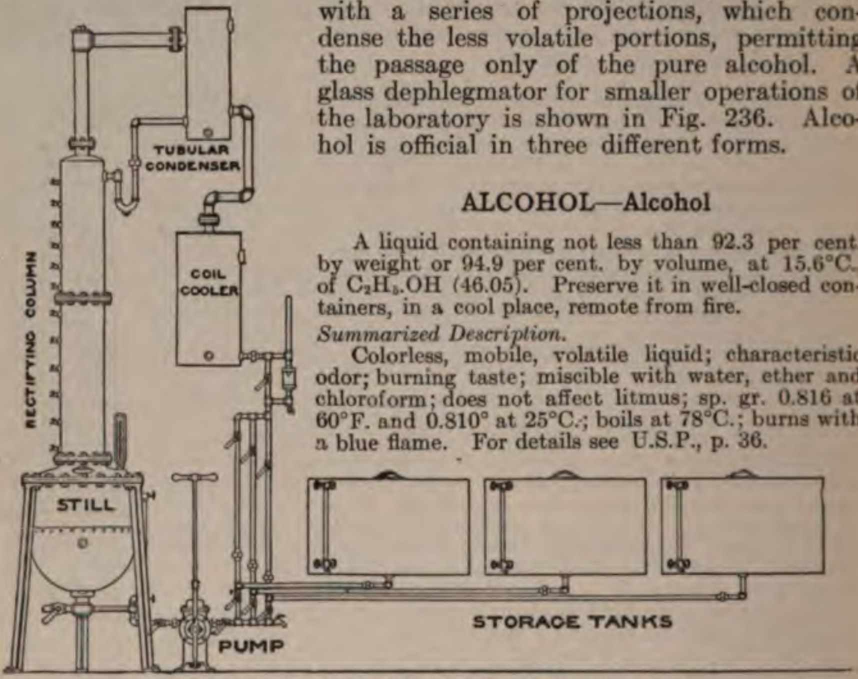


Fig. 235.—Rectifying still, with column and condensers.

ALCOHOL—Alcohol

A liquid containing not less than 92.3 per cent. by weight or 94.9 per cent. by volume, at 15.6°C., of $C_2H_5.OH$ (46.05). Preserve it in well-closed containers, in a cool place, remote from fire.

Summarized Description.

Colorless, mobile, volatile liquid; characteristic odor; burning taste; miscible with water, ether and chloroform; does not affect litmus; sp. gr. 0.816 at 60°F. and 0.810° at 25°C.; boils at 78°C.; burns with a blue flame. For details see U.S.P., p. 36.

For *tests for identity*, for *impurities:* fusel oil (mixed with glycerin, leaves no odor on blotting paper). Amyl alcohol, etc. (neither opalescent nor faint brown with silver nitrate). Aldehyde or oak tannin (not immediately yellow with potassium hydroxide). Methyl alcohol (no formaldehyde reaction with sulphuric acid and fuchsin-sulphurous acid reagent, when it is diluted and oxidized with acid permanganate). Acetone (sodium hydroxide, sodium nitroprusside and acetic acid give no purple color.) (See U.S.P., p. 36.)

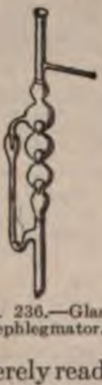


Fig. 236.—Glass dephlegmator.

Remarks.—This represents the most concentrated form of ethyl hydroxide which can be produced by the simple process of dephlegmation. It contains 92.3 per cent., by weight (94.9 per cent., by volume), of ethyl hydroxide and is practically the *deodorized alcohol* of the pharmacopœia of 1890.

It is very important to be able readily to determine the strength of any individual sample of alcohol on hand, and this is usually accomplished by means of that form of hydrometer called the alcoholometer (already described on p. 51), which is usually provided with a scale which not merely reads its specific gravity, but also the actual percentage of alcohol in the sample. Of course, the strength can be ascertained by taking the specific gravity in any other manner, in which event, however, reference must be had to the alcohol table found in the pharmacopœia. (See U.S.P.)

It will be noticed that the pharmacopœial monograph includes a test for wood alcohol. This is based upon the fact that grain alcohol treated with a dilute acidulated permanganate solution does not oxidize to aldehyde, while wood alcohol so treated yields formaldehyde. The fuchsin-sulphurous acid reaction given in the test shows the presence of formaldehyde. (See p. 585.)

ALCOHOL DEHYDRATUM—Dehydrated Alcohol

(Alcohol Dehyd.—Alcohol Absolutum U.S.P. VIII)

A liquid containing not less than 99 per cent. by weight of $C_2H_5.OH$ (46.05). Preserve it in well-closed containers, in a cool place, remote from fire.

Summarized Description.

Colorless, mobile, volatile liquid; characteristic odor; burning taste; very hygroscopic; sp. gr. 0.790 at 25°C; otherwise like alcohol. For details see U.S.P., p. 36

For *tests for identity,* for *impurities:* Water (does not blue, anhydrous copper sulphate) see U.S.P., p. 36.

Remarks.—Dehydrated alcohol, or *absolute alcohol,* is a liquid containing not less than 99 per cent. of ethyl hydroxide, and is made from ordinary alcohol by redistillation from lime. In order to get same "absolutely absolute," which is sometimes necessary in very careful chemical work, it is mixed with metallic sodium, which absorbs all the water (forming sodium hydroxide), and also some of the alcohol (forming sodium alcoholate, C_2H_5ONa), and then distilling into a flask closely fitted to the condenser, and with orifices for air closed by means of calcium chloride drying tubes.

To tell whether absolute alcohol is completely dehydrated is usually accomplished by throwing into same a small amount of exsiccated copper sulphate. This is of grayish-white color, and if there is any water in the alcohol, the copper salt absorbs same, becoming partly crystallized, and assuming a blue tint.

ALCOHOL DILUTUM—Diluted Alcohol

(Alcohol Dil.)

A liquid containing from 41 to 42 per cent. by weight or from 48.4 to 49.5 per cent. by volume, at 15.56°C., of $C_2H_5.OH$ (46.05). Preserve it in well-closed containers, in a cool place, remote from fire.

Condensed Recipe.

Mix together 500 mils of alcohol and 500 mils of water; at 25°C. the product will measure about 970 mils. Or else, mix 408 Gm. alcohol with 500 Gm. water.

Summarized Description.

Responds to reactions and tests given under alcohol; however, its specific gravity is from 0.930 to 0.932 at 25°C. For details see U.S.P., p. 37.

Remarks.—Diluted alcohol, U.S.P., is made by mixing equal volumes of alcohol and water, and since U.S.P. alcohol is 92.3 per cent., by weight, of ethyl hydroxide, the dilute alcohol is 41 per cent., by weight, of the same chemical. This is shown in the following figures:

100 mils of 92.3 per cent. alcohol (sp. gr. 0.820) weighs 82 Gm.

	100 mils or 82 Gm. 92.3 per cent. alcohol.
plus	100 mils or 100 Gm. water
makes	200 mils or 182 Gm. of diluted alcohol.

The 82 Gm. 92.3 per cent. alcohol contain 92.3 Gm. absolute alcohol.

$$(82 \times 0.923 = 75.68)$$

Hence the 182 Gm. diluted alcohol contain the same—

75.68 Gm. absolute alcohol.

What percentage of 182 is 75.68?

$$\frac{75.68}{182.00} \times 100 \text{ per cent., or about } 41.5 \text{ per cent.}$$

Note that 100 mils alcohol and 100 mils water do not make 200 mils diluted alcohol, and this variation from the theoretic is due to the interesting fact that when alcohol and water are mixed, contraction occurs, as explained on p. 123.

It is important to know that diluted alcohol, U.S.P., is not the "proof spirit" of the Internal Revenue Department of the government; the latter means 50 per cent. by volume of ethyl hydroxide, while the dilute alcohol, U.S.P., is from 48 to 49 per cent. by volume. As is usual with commercial standards, the Internal Revenue grading is wholly unscientific.

In choosing 50 per cent. by volume as "proof," possibly a correct standard was made, as it is assumed that most whisky is about that strength. However, the strength, either above or below this point, is designated in a most unfortunate manner, viz., by saying that sample is "ten below proof" or "twenty above proof." Twenty above proof does not mean 70 per cent. by volume, but indicates that 100 parts of such 20 above proof sample are to be diluted with water enough to make 120 parts in order to make it "proof." In other words, "20 above proof" means 60 per cent. by volume.

Still more unfortunate is it that British excise "proof" is not the same as the standard of the Internal Revenue of our country, but represents 50 per cent., by weight, of absolute alcohol.

The rule for alcohol mixing given by the pharmacopœia is simply the expression, in another form, of the rule of alligation given on p. 59.

Ethyl Oxide $(C_2H_5)_2O$.—This product is official as Æther.

ÆTHER—Ether

A liquid containing not less than 95.5 per cent. nor more than 97.5 per cent. of ethyl oxide [$(C_2H_5)_2O = 74.08$], the remainder consisting of alcohol containing a little water. Preserve it in partially filled, well-closed containers, in a cool place, remote from fire, and protected from daylight.

When Ether is to be used for anesthesia it is to be dispensed only in small, well-closed containers and is not to be used for this purpose if the container has been opened longer than twenty-four hours.

Summarized Description.

Colorless, mobile liquid; characteristic odor; burning sweetish taste; soluble in about 12 volumes of water; miscible with alcohol, chloroform, petroleum benzin, benzene, fixed and volatile oils; sp. gr. 0.713 to 0.716; boils at 35°C.; very volatile and inflammable; vapor mixed with air, very explosive; air, moisture and sunlight produces peroxides in it. For details see U.S.P., p. 32.

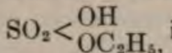
For *tests for identity*, for *impurities:* aldehyde (no color on shaking with solution of potassium hydroxide). Peroxides (no color on shaking with solution of cadmium and potassium iodide) see U.S.P., p. 33.

Impurities.—Aldehyde and peroxides. Details above.

Remarks.—While ether was known to Raymond Lully (1253–1315), the present method of manufacture was devised by Valerius Cordus in the middle of the fifteenth century. It is made by treating alcohol with sulphuric acid and distilling immediately.

As explained on p. 572, the reaction may be simply expressed as being produced by taking water away from alcohol, sulphuric acid acting as the dehydrating agent. This theory of ether formation proposed by Fourcroy and Vauquelin (1797) was accepted until later investigations proved that while true as to ultimate results, the actual process was not so simple as the mere removal of water by mechanical means. The factor contributing to the rejection of the theory was the fact that if the water was absorbed by the sulphuric acid, it would be closely retained by same, when, as a matter of fact, it is noted that a portion of the water distils over with the ether.

The next theory was the "contact theory" of Mitscherlich, that the ether production was due to catalysis, the latter word a term found very convenient by chemists for the first half of the last century for explaining chemical changes which were not really understood.

The discovery of the real process was made by Liebig (1839), who proved that, during the formation of ether, an intermediate product, ethylsulphuric acid,  $SO_2<\begin{matrix}OH\\OC_2H_5\end{matrix}$, is produced.

This is sometimes called "*sulphovinic acid*," and forms salts, one of which, sodium sulphovinate, had some medical prominence some years since, being recommended by Dr. Rabuteau as a purgative in doses of 25 grammes.

Liebig's discovery of ethyl-sulphuric acid was supplemented by the researches of Williamson (1850), whose complete theory of ether formation is now accepted as truth.

According to this, alcohol treated with sulphuric acid forms ethyl-sulphuric acid and water (equation *a*). This ethyl-sulphuric acid comes in contact with more alcohol, liberating ether and sulphuric acid (equation *b*):

$$(a)\ C_2H_5OH + H_2SO_4 = C_2H_5SO_4H + H_2O.$$
$$(b)\ C_2H_5SO_4H + C_2H_5OH = (C_2H_5)_2O + H_2SO_4.$$

It will be noted that the above reaction finishes with as much acid as it began with, and this is a fact, a small quantity of sulphuric acid being capable of etherizing a large quantity of alcohol.

The only reason why the same sulphuric acid cannot be used indefinitely is the fact that the acid finally becomes so greatly diluted with water that it is incapable of further chemical action.

As to the practical details of ether formation, the sulphuric acid is placed in a suitable container (still body), gently warmed, and upon it the alcohol is allowed to trickle slowly. Contact of the alcohol with the acid is followed by the formation of ether, which is immediately distilled. The distillate usually contains about 74 per cent. of ethyl oxide, and in this form was official in the pharmacopœia of 1880. The greater portion of the alcohol can be removed by cautious distillation, and ether, U.S.P., which was called *æther fortior* in U.S.P. 1880, is directed to contain from 95.5 to 97.5 per cent. of ethyl oxide.

Ether can be made from Pintsch gas, a product of the destructive distillation of petroleum. With the use of tax-free alcohol, however, ether can be made cheaper from that source than from Pintsch gas.

Ether is a clear, limpid liquid of specific gravity 0.716, boiling at 37°C., and as it is exceedingly volatile, must be kept in tightly closed bottles away from a flame. It is used in pharmacy as a solvent, being the menstruum formerly directed in the preparation of the oleoresins.

Some samples of ether have been known to explode as the last portions are being distilled. This phenomenon is due to presence of hydrogen dioxide in the sample distilled and it will be noted above that the present pharmacopœia gives a test for peroxides.

Its medicinal use is as an anesthetic, while in minute quantities it acts as a sedative.

Dose.—1 mil (15 minims).

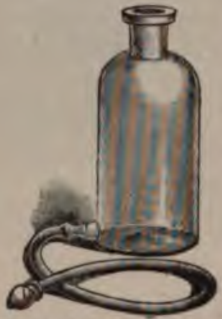


Fig. 237.—Nasal douche bottle.

Syrup of ether of the French Codex is well adapted for administration of ether as a sedative. This is made by agitating 500 parts of syrup with 30 parts of ether in a bottle provided with an orifice at the bottom (the Thudicum nasal douche bottle, Fig. 237, with rubber tube replaced by a cork). Ether is macerated with the syrup for five or six days with occasional agitation; then it is allowed to stand, and the clear syrup drained off from the ethereal mixture, which floats on the surface. This is the only satisfactory way of making syrup of ether.

Schleich's solution was introduced some years ago as the safest form of anesthetic.

There are three forms of the solution recommended by Dr. Schleich for anesthesia for short, moderate, or long periods respectively:

I. Chloroform 45, ether 180, petroleum ether 15. Boiling-point, 38°C.

(B.P. 60°–65°)

II. Chloroform 45, ether 150, petroleum ether 15. Boiling-point, 40°C.

III. Chloroform 30, ether 80, petroleum ether 15. Boiling-point, 42°C.

It is an open question as to whether such mixtures ever possess definite boiling-points.

In dispensing these the pharmacist must be careful to use petroleum ether and not commercial benzin. For similar purposes is the "*A. C. E. Mixture,*" which consists of alcohol, 1 fluidounce; chloroform, 2 fluidounces, and ether, 3 fluidounces. This is very popular in English hospitals.

Two much used preparations of ether are *spirit of ether* U.S.P. (p. 179) and *compound spirit of ether* N.F. (p. 182).

The following esters of ethyl hydroxide are important pharmaceuticals.

SPIRITUS ÆTHERIS NITROSI—Spirit of Nitrous Ether

(Sp. Æth. Nitros.—Sweet Spirit of Nitre)

An alcoholic solution of ethyl nitrite [$C_2H_5NO_2 = 75.05$], containing not less than 3.5 per cent. nor more than 4.5 per cent. of $C_2H_5NO_2$. Preserve it in small, well-stoppered, dark amber-colored bottles, in a cool and dark place, remote from fire.

Condensed Recipe.

Mix 40 mils of sulphuric acid with 120 mils of water and after cooling, add 170 mils of diluted alcohol and chill in a freezing mixture. Add to this liquid little by little a solution of 100 Gm. sodium nitrite, in 280 mils of water. Separate the ethyl nitrite resulting from the reaction and wash with iced water, then with a chilled sodium carbonate solution and lastly dry with cold dehydrated potassium carbonate. The ethyl nitrite thus purified is poured into 500 Gm. alcohol contained in a tared flask and the solution is then weighed. Having thus ascertained the weight of the ethyl nitrite, add enough alcohol to make the finished spirit weigh twenty-two times as much as the ethyl nitrite used. For details see U.S.P., p. 403.

Summarized Description.

Clear, mobile, volatile inflammable liquid; pale yellow or faint green-yellow color; fragrant ethereal odor; sharp burning taste; neutral to litmus when fresh; becomes acid on exposure to light and air; should not effervesce with potassium bicarbonate; sp. gr. 0.823; boils under proper conditions at 65°C.

For details see U.S.P., p. 404.

For *tests for identity,* for *impurities:* aldehyde (should not turn yellow or brown when treated with potassium hydroxide solution) see U.S.P., p. 404 and also Part V of this book.

Outline of Assay.—An aliquot part of a neutral alcoholic solution representing the exact weight of about 4 mils of the spirit is mixed, in a nitrometer with 10 mils of potassium iodide T.S. and with 5 mils of diluted sulphuric acid. The gas evolved by the reaction is measured (in between 20 and 60 minutes) and the temperature and the barometric pressure is taken. The factor of calculation is

$$\frac{\text{mils of gas} \times 0.307}{\text{Weight of spirit taken}} = \text{percentage of ethyl nitrite.}$$

For the correction of this to observed temperature and barometric pressure see U.S.P., p. 404.

Remarks.—The manufacture of this body, as already outlined on p. 572, is performed by treating alcohol with nitrous acid in the presence of sulphuric acid. Nitrous acid itself is rather an unstable compound, hence in the official preparation it is obtained by treating sodium nitrite with sulphuric acid. Besides, in this and all other esters, a dehydrating agent (usually sulphuric acid) is necessary to remove the water which is the side product in ester formation (p. 572).

While the processes of manufacture of spirit of nitrous ether in the present pharmacopœia and in that of 1890 are similar as far as the formation of ethyl nitrite is concerned, the two recipes differ materially as to the separation of the ethyl nitrite from the reacting solution. The recipe of the present pharmacopœia provides that the reaction take place in a vessel surrounded by a freezing mixture, and that the ethyl nitrite formed (insoluble in and lighter than water) be separated from the aqueous layer, freed from acid by treatment with sodium carbonate solution, and from water by use of exsiccated potassium carbonate, and then mixed with twenty-one times its weight of alcohol.

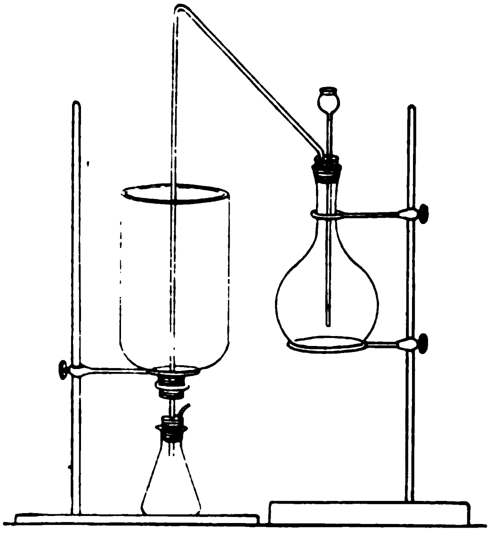


Fig. 238.—Upright condenser for spirit of nitrous ether, U.S.P. 1890.

In the process of 1890 the reaction takes place at normal temperatures, and the ethyl nitrite is separated by distillation, the details being as follows:

In a capacious flask is placed sodium nitrite dissolved in water and the alcohol. The flask is tightly fitted with a two-hole cork, through one hole of which passes a separatory funnel, while through the other passes a glass tube connected with an appropriate series of condensers. The sulphuric acid is diluted with water, and while still warm the mixture is allowed to trickle on the sodium nitrite solution in the flask through the separatory funnel.

This causes the following reactions:

$$2NaNO_2 + H_2SO_4 = Na_2SO_4 + 2HNO_2.$$
$$C_2H_5OH + HNO_2 = C_2H_5NO_2 + H_2O.$$

The ethyl nitrite liberated, being very volatile, passes over into the condenser, from which it emerges as a light yellow liquid, having the odor of apples, boiling at 18°C., and with specific gravity 0.900 at 15°C. From this ethyl nitrite traces of acid are removed by washing with a cold solution of sodium carbonate, and the ester is then freed from water by treating with dried potassium carbonate and finally mixed with twenty-one times its own weight of alcohol.

In order to obtain a good yield of the exceedingly volatile ethyl nitrite great care must be taken for thorough condensation. This is best accomplished by the apparatus shown in Fig. 238, where the vapors are first passed up a tall tube and then passed down in the smaller flask, in transit passing through a layer of ice and salt. By such a method a yield as large as 52 Gm. has been obtained from 55 mils alcohol, the theoretic yield being 67 Gm. of nitrite from 55 mils alcohol.

The actual operation runs smoothly, provided due care is taken that the ethyl nitrite passes over regularly and without sudden rushes. This is accomplished by constantly agitating the reaction flask. If this is not done, the liquid in the flask forms two layers, the sulphuric acid being below and the sodium nitrite solution above. If these two layers are permitted to form, agitation may result in a sudden production of large quantities of ethyl nitrite with sufficient force to cause an explosion. The temperature of the reaction is usually sufficient to distil over all the ethyl nitrite formed. However, it is a matter of wisdom to finish the operation after the reaction appears to have ceased, by gently warming the mixture by means of a water-bath.

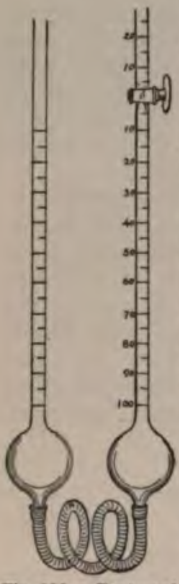


Fig. 239.—Curtman's nitrometer.

The finished spirit of nitrous ether is an alcoholic solution of pure ethyl nitrite, and does not represent the original *sweet spirit of nitre*, which was prepared by distilling alcohol with a mixture of nitric and sulphuric acids. The alcohol in the latter case acts as a reducing agent on the nitric acid, and, inversely, the nitric acid oxidizes certain portions of alcohol, with formation of aldehyde. The reactions are as follows:

$$CH_3CH_2OH + HNO_3 = CH_3CHO + HNO_2 + H_2O.$$
$$C_2H_5OH + HNO_2 = C_2H_5NO_2 + H_2O.$$

Fresh spirit of nitrous ether contains 4 to 5 per cent. of ethyl nitrite, and as it rapidly deteriorates on standing, should be either freshly prepared or assayed from time to time. The method of assaying is not difficult and quite interesting.

In the present pharmacopœia the process is made exact and complex by using a weighed amount of the spirit; in the pharmacopœia of 1890 it was directed that 5 mils of the spirit should be poured into an appropriate nitrometer, and that there be then added solution of potassium iodide and diluted sulphuric acid, whereupon the resulting decomposition yielded the gas NO or N_2O_2, as shown in the following equation:

$$C_2H_5NO_2 + KI + H_2SO_4 = C_2H_5OH + KHSO_4 + I + NO$$

The nitrometer is a graduated tube shown in Fig. 239, but in lieu of the expensive apparatus fair results can be obtained by using a Squibb urea apparatus.

The gas, N_2O_2, forces down the salt water with which the nitrometer is filled, and thus the volume of the gas evolved can be easily read. The 5 mils of ethyl nitrite should yield 55 mils of nitrogen dioxide gas. The present pharmacopœia also directs that the volume of N_2O_2 gas be adjusted to the temperature 25°C. and the barometric pressure of 760 mm. of mercury. (See p. 595.)

The arithmetic of the above statement that 5 mils spirit of nitrous ether should yield 55 mils nitrogen dioxide is as follows:

5 mils spirit (sp. gr. 0.823) weigh $5 \times 0.823 = 4.115$ Gm.

4.115 Gm. spirit (4 per cent.) contain $4.115 \times 0.04 = 0.1646$ Gm. ethyl nitrite.

$$\underset{74.15}{C_2H_5NO_2} + KI + H_2SO_4 = C_2H_5OH + KHSO_4 + I + \underset{29.81}{NO}$$

We see from the above equation that

74.15 Gm. ethyl nitrite yield 29.81 Gm. nitrogen dioxide.

Then 0.1646 Gm. ethyl nitrite yields $^{1646}/_{741500} \times 29.81$ Gm. nitrogen dioxide, or 0.0661 Gm. nitrogen dioxide.

1000 mils nitrogen dioxide weigh 1.2281 Gm. (page 924).

Then 0.0661 Gm. nitrogen dioxide measures $^{661}/_{12281} \times 1000$ mils, or 53.8 mils.

Hence, it will be seen that a spirit of nitrous ether, 5 mils of which will yield 55 mils nitrogen dioxide gas, must contain slightly more than 4 per cent. ethyl nitrite.

Sweet spirit of nitre, as the preparation is popularly called, is valuable as a febrifuge and diuretic.

Dose.—2 mils (30 minims).

Æther Aceticus (U.S.P. VIII; N.F. IV), or *acetic ether*, contains at least 96 per cent. by volume of ethyl acetate $C_2H_5C_2H_3O_2$. The method of manufacture is similar to that of ethyl nitrite, namely, treating alcohol with sodium acetate and sulphuric acid by the following reaction:

$$C_2H_5OH + NaC_2H_3O_2 + H_2SO_4 = C_2H_5C_2H_3O_2 + NaHSO_4 + H_2O.$$

The sodium acetate and alcohol are mixed in the distilling flask and the sulphuric acid allowed to trickle in from a separatory funnel, the mixture warmed, and the resulting ethyl acetate distilled.

Acetic ether is a liquid of very delightful odor, and is one of the most popular of the fruit ethers used in preparing artificial flavoring extracts, the other ethers utilized for the purpose being butyric ether, amyl acetate, and pelargonic ether.

Acetic ether is of considerable value in organic chemistry as a crystallizing solvent. It has but little medicinal use but is sometimes given as a stimulant in 15-minim doses.

Ethyl Sulphate $(C_2H_5)_2SO_4$.—This is a constituent of the official ethereal oil.

Oleum Æthereum (U.S.P. VIII; N.F. IV), or *ethereal oil*, is manufactured by treatment of alcohol with sulphuric acid, allowing the mixture to macerate for twenty-four hours, then pouring same into a retort, and distilling the mixture until the frothy residue of the retort rises to the point where there is danger of it running over. This reaction yields varying quantities of ethyl sulphate and ethylsulphovinate, and the resulting product, called "*heavy oil of wine*," is dissolved in an equal volume of ether.

In the process large quantities of ether are formed, for it will be noticed that the product is manufactured by a method very similar to that of the manufacture of ether and with exactly the same constituents, the difference in the manufacture being summed up briefly as follows: Alcohol plus sulphuric acid plus immediate distillation gives ether. Alcohol plus sulphuric acid plus distillation, after standing, gives ethereal oil.

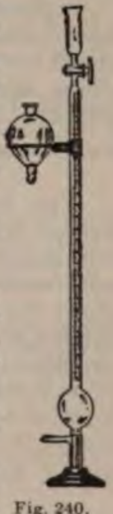


Fig. 240. Bradley nitrometer.

The yield of ethereal oil is about 20 mils of the Formulary product from 1100 mils alcohol, an output so small as to be scarcely worth the pharmacist's time to manufacture. The very fact, however, that the yield is small makes the ethereal oil very expensive, and hence liable to adulteration, and it is said that the larger amount of the so-called ethereal oil on the market consists merely of the last distillate in the process of the manufacture of ether, and even this is sometimes adulterated, one of the favorable adulterants being castor oil, which liquid has about the same specific gravity as ethereal oil. This falsification, however, can be easily detected by reason of the permanent greasy stain that such ethereal oil will leave on filter-paper, whereas true ethereal oil is uniformly volatile. Ethereal oil is a light yellow liquid, having a peculiar penetrating odor, used as a constituent of *compound spirit of ether*, N.F., and is in itself a stimulant.

The manufacture of ethereal oil gives interesting proof of the presence of carbon in alcohol, the residue from the distillate of a mixture of pure sulphuric acid and alcohol consisting primarily of carbon.

Æthylis Carbamas (U.S.P.).—*Ethyl carbamate* can best be considered among the compounds of carbonic acid (p. 676).

Acetaldehyde is the aldehyde of ethyl alcohol, and its original name has been shortened and employed as the name for the entire class of aldehydes, even as the class called alcohols are named after the original type, grain alcohol.

Aldehyde was discovered by Fourcroy and Vauquelin in 1800. Liebig, observing that aldehyde differed from alcohol in the loss of hydrogen atom, named the finished product "alcohol dehydrogenatus." By combining the first syllables of the two words the name aldehyde was devised.

It will be noticed that the aldehydes are not named after the hydrocarbons from which derived, but from the acids they yield on oxidation. Thus the aldehyde under consideration is never called ethyl aldehyde, but acetaldehyde, likewise the aldehyde of methyl is not called methyl aldehyde, but formaldehyde, because eventually yielding formic acid.

Ordinary aldehyde is CH_3CHO; like other aldehydes, it is made by the oxidation of the corresponding alcohol—in this case, ethyl alcohol. Ethyl alcohol is C_2H_5OH, and its formula can be written CH_3CH_2OH, or even CH_3CHHOH.

Suppose this be oxidized by bringing it in contact with some substance yielding oxygen, like potassium dichromate and sulphuric acid—we get a reaction like the following, the underscored hydrogen and oxygen atoms separating as water, the new oxygen atom going into the compound:

$$CH_3CH\underline{HOH} + O = H_2O + CH_3CHO \text{ (acetaldehyde).}$$

The manufacture of aldehyde is accomplished by treating ethyl alcohol with a mixture of potassium dichromate and sulphuric acid, a very simple and pretty experiment. The orange-red solution of chromic acid formed when potassium dichromate and sulphuric acid are mixed shows the process of oxidation by changing to green as it parts with its oxygen, the green color being due to the formation of chromium sulphate, $Cr_2(SO_4)_3$. Aldehyde is a liquid of characteristic odor, boiling at 21°C.

It is not official, but its polymer, paraldehyde, is accorded pharmacopœial recognition.

PARALDEHYDUM—Paraldehyde

(Paraldehyd.)

A polymer [$(CH_3CHO)_3 = 132.10$] of acetaldehyde. Preserve it in well-closed containers, in a cool place, protected from light.

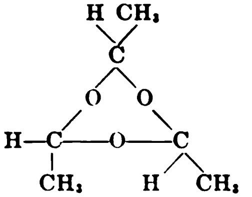
Summarized Description.—

Colorless transparent liquid; strong, characteristic but not unpleasant odor; burning then cooling taste; soluble in 8 volumes of water; miscible with alcohol, chloroform, and ether; sp. gr. 0.990; boils at 120° to 125°C., congeals at about 6°C. For details see U.S.P., p. 311.

For *tests for identity*, for *impurities:* fusel oil derivatives (no disagreeable odor left on evaporation). Amyl alcohol (no oily drops on dissolving in water). Sulphuric acid (no turbidity with barium chloride). Hydrochloric acid (no opalescence with silver nitrate). Free acid (a type of titration with normal alkali). Acetaldehyde (not yellow or brown with potassium hydroxide). For details see U.S.P., p. 311.

Remarks.—This body represents the condensation of three molecules of aldehyde, hence has the formula $(C_2H_4O)_3$.

This is the first example of condensation we have considered, and it is of interest to know that such does not merely mean the compression of three molecules of a substance into one molecule of a new compound, but that in this process of changing, the character of the compound becomes considerably altered. Thus to paraldehyde is given the structural formula—



The condensation of aldehyde to paraldehyde is accomplished by passing hydrochloric acid gas through the former. Paraldehyde is a liquid of peculiar, pungent odor, specific gravity 0.99, boiling between 120° and 125°C. It is a sedative and hypnotic of particular value in cases of delirium tremens.

Dose.—2 mils (30 minims).

CHLORALUM HYDRATUM—Hydrated Chloral

(Chloral. Hydrat.—"Chloral"—Chloral Hydrate)

A compound of trichloraldehyde or chloral, with the elements of one molecule of water. It contains not less than 99.5 per cent. of $C_2HCl_3O + H_2O$ or $CCl_3{\cdot}COH + H_2O$ (165.4). Preserve it in tightly stoppered bottles, in a cool place, protected from light.

Summarized Description.

Rhombohedral, colorless crystals; aromatic penetrating slightly acrid odor; bitterish caustic taste; slowly volatile; soluble in about 0.25 part of water, in about 1 part of alcohol, in about 3 parts of chloroform, and in about 1.1 parts of ether; also soluble in fixed oils and in oil of turpentine; decomposed by alkalies into chloroform and a formate. For details see U.S.P., p. 108.

For *tests for identity*, for *impurities:* chloral alcoholate or ethyl carbonate (vapors on ignition are not inflammable). Hydrochloric acid and chlorides (alcoholic solution not made turbid by silver nitrate). Organic impurities (does not darken concentrated sulphuric acid) and for *assay* see U.S.P., p. 108 and also Part V of this book.

Remarks.—Chloral hydrate was discovered by Liebig in 1832, but was considered merely as an interesting chemical rarity until its real value as a sedative was discovered in 1869 by Liebreich.

The former pharmacopœial name, *chloral*, is a misnomer, as the true chloral is a liquid which, on addition of one molecule of water, forms the crystalline official substance.

Chloral is an aldehyde, the three hydrogen atoms of whose methyl group are replaced by chlorine, as shown by comparison of formulas:

CH_3CHO	CCl_3CHO
Aldehyde.	Chloral.

Chloral is made by passing chlorine gas through alcohol. Chlorine acts as an oxidizing agent—that is, it is one of those substances by which oxygen can be brought in contact with and united to a body. We have seen just above that alcohol, when oxidized, is converted into aldehyde. When chlorine is employed as the oxidizing agent, it also replaces the hydrogen of the aldehyde forming chloral. The stages of the process are:

$$\begin{array}{ccccc} CH_3CHHOH & \rightarrow & CH_3CHO & \rightarrow & CCl_3CHO \\ \text{Alcohol.} & & \text{Aldehyde.} & & \text{Chloral.} \end{array}$$

The complete equation of the manufacture of chloral from alcohol is as follows:

$$\begin{array}{lllllll} CH_3CH_2OH & + & Cl_2 & = & CH_3CHO & + & 2HCl. \\ CH_3CHO & + & Cl_6 & = & CCl_3CHO & + & 3HCl. \end{array}$$

In manufacturing chloral by this process there is usually produced, besides chloral hydrate, a body, chloral alcoholate, $CCl_3CH\begin{matrix}-OH \\ -OC_2H_5\end{matrix}$, the therapeutic effect of which is quite harmful, and hence great caution should be taken to avoid same in official chloral. The pharmacopœial test for its detection is given above.

Chloral alcoholate is removed during the manufacture of chloral hydrate by upright distillation from concentrated sulphuric acid. This decomposes the alcoholate, while pure chloral is unchanged.

Chloral hydrate is a white solid, occurring in crystals or in white amorphous scales. It is very soluble in water.

As stated above, chloral hydrate is quite soluble in water, and, therefore, it is used to prepare a so-called 100 per cent. solution, that is, a solution of one avoirdupois ounce to a fluidounce. However, it is scarcely worth while to keep the solution on hand, as it can be so easily prepared, and, moreover, the solution spoils on standing, the chloral decomposing into formic and hydrochloric acids.

Chloral hydrate should never be dispensed in alkaline solution, as during the reaction chloroform is produced:

$$\begin{array}{ccccccc} CCl_3CHO & + & KOH & = & CHCl_3 & + & KCOOH \\ \text{Chloral.} & & \text{Potassium hydroxide.} & & \text{Chloroform.} & & \text{Potassium formate.} \end{array}$$

This, as noted on p. 580, is a method of making very pure chloroform.

Chloral hydrate is one of the most valuable hypnotics, but, on the other hand, its abuse is one of the most dangerous of the many drug habits.

Dose.—500 milligrammes (8 grains).

Chloral hydrate, when rubbed with camphor, thymol, or menthol, is converted into a thick, viscid liquid, the former, under the name *chloral camphor*, has considerable vogue as a local sedative for gumboils and the like, and, according to the National Formulary, is made by rubbing together equal quantities of chloral and camphor until liquefied.

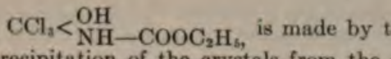
Quite a number of derivatives of chloral are used as medicines.

Chloral formamidum (U.S.P. VIII), or *chloral formamide*, is made by treating anhydrous chloral with formamide, as expressed in the following equation:

$$\begin{array}{ccccc} \text{Chloral.} & & \text{Formamide.} & & \text{Chloral formamide.} \\ CCl_3CHO & + & HCONH_2 & = & CCl_3CH<\begin{matrix}OH \\ NHCOH,\end{matrix} \end{array}$$

and is typical of a large number of condensation products of chloral where the group $-C\begin{matrix}-H \\ =O\end{matrix}$ is converted into the group $-C\begin{matrix}-H \\ -OH \\ -R,\end{matrix}$ "R" meaning any radicle with on free bond.

Chloralformamide (or *chloralamide*, as it is sometimes called) is used as a hypnotic, in 15-grain doses.

Ural, or *chloralurethane*,  $CCl_3<\genfrac{}{}{0pt}{}{OH}{NH—COOC_2H_5}$, is made by the combination of chloral and urethane and precipitation of the crystals from the reacting liquid by addition of concentrated hydrochloric acid.

Ural is in the form of transparent crystals melting at 103°C., insoluble in water, and used as a hypnotic. *Somnol* is ethylated ural. (See page 677.)

Hypnal is a mixture of *chloral* (45 per cent.) and *antipyrine* (55 per cent.). It melts at 58°C., and is used as a hypnotic in 15-grain doses.

Acetic Acid (CH_3COOH).—This important compound was known to the ancients in the form of vinegar, a product of the fermentation of wine. The concentrated form of acetic acid was not known until 1700, when prepared by Stahl, its production being accomplished only after it was discovered that one of the products of the destructive distillation of wood was acetic acid, this discovery being made by Glauber in 1648, who called the finished product *wood vinegar*.

The chemical analysis of absolute acetic acid was not accomplished until 1814, when Berzelius gave careful study to the structural character of the compound.

Acetic acid occurs naturally in the sap of some plants, is usually a constituent of sweat, and is found as organic esters in some oils; thus, croton oil contains acetin (glyceryl acetate).

Acetic acid has been produced by synthesis from carbon disulphide.

Carbon disulphide plus chloroform gives carbon tetrachloride, CCl_4.

This body, under treatment with metallic sodium, gives ethylene chloride, $C_2H_4Cl_2$, and eventually ethane hexachloride, C_2Cl_6. Ethane hexachloride treated with water yields trichloracetic acid, CCl_3COOH, and this, by reduction, gives acetic acid.

Of course, the above method is of purely theoretic interest, the actual manufacture of acetic acid being either from the distillation of wood or by the oxidation of alcohol.

The latter, when diluted and under the influence of the mother of vinegar, *Mycoderma aceti*, is converted into vinegar, which represents a weak acetic acid. The commercial acetic acid, however, is produced by the destructive distillation of wood.

As already explained on p. 584, wood, on being subjected to heat, yields a tarry distillate, called crude pyroligneous acid (*pyros*, meaning fire, and *lignum*, wood), which is composed chiefly of wood alcohol, acetic acid, and acetone.

The separation of acetic acid from this distillate has already been given, so suffice it to say that a very large quantity of acid is produced by such treatment of wood, and it has been found that the great heat formerly thought necessary to decompose same is unnecessary.

Acetic acid can best be prepared by cutting oak wood in appropriate sized billets, putting into a retort, and heating under 218°C.; at this temperature wood does not char, and except for darkening in color after the process, appears as original wood. The residue is simply dried, and is then sold for fuel.

Acetic acid is official in three distinct strengths.

ACIDUM ACETICUM GLACIALE—Glacial Acetic Acid

(Acid. Acet. Glac.)

A liquid containing not less than 99 per cent. of $C_2H_4O_2$ or CH_3COOH (60.03). Preserve it in glass-stoppered bottles.

Summarized Description.

Clear colorless liquid; strong odor like vinegar; pungent acid taste; miscible with water or alcohol; sp. gr. 1.047 to 1.050; boils at 117° to 118°C.; congeals at about 14.5°. For details see U.S.P., p. 7.

Tests for identity and for *impurities* like those for acetic acid, except the permanganate test. For *assay* see U.S.P., p. 7 and also Part V of this book.

Remarks.—This glacial acetic acid must contain at least 99 per cent. CH_3COOH, and is called "glacial," because at temperatures below 15°C. it becomes solid, like ice. Some manufacturers have put upon the market an acetic acid labeled "glacial," but on careful examination of the label it is found that in smaller type are the words 80 per cent. That such procedure is dishonest goes without saying. Glacial acetic acid is very valuable as a solvent for a great diversity of substances; thus it dissolves resins, glue, and a large number of other organic bodies. Its use in this way, however, must be with caution, as there is strong likelihood of its forming chemical combinations.

ACIDUM ACETICUM—Acetic Acid

(Acid. Acet.)

An aqueous solution containing not less than 36 per cent. nor more than 37 per cent. of $C_2H_4O_2$ or CH_3COOH (60.03).

Summarized Description.

Clear colorless liquid; strong odor like vinegar; sharply acid taste; miscible with water or alcohol; sp. gr. about 1.045. For details see U.S.P., p. 6.

For *tests for identity*, for *impurities:* heavy metals (hydrogen sulphide test) sulphuric acid (barium chloride test). Hydrochloric acid (silver nitrate test). Formic or sulphurous acid (does not reduce ammoniacal silver nitrate. Empyreumatic substances (does not decolorize definite amount of permanganate solution) and for *assay* see U.S.P., p. 6 and also Part V of this book.

Remarks.—Acetic acid contains 36 per cent. absolute acetic acid, and should be ordered as 36 per cent. acid. The ordinary commercial acetic acid, familiarly called "No. 8," is not the pharmacopœial acid. It contains but 29 to 30 per cent. of absolute acetic acid. The fact that No. 8 acetic acid is not pharmacopœial was learned by a friend of the writer at considerable expense, inasmuch as he dispensed No. 8 acid when acetic acid was called for, and afterward had to answer the charge of violation of the pure food laws of his State. This should warn all pharmacists to exercise the utmost caution in dispensing commodities under pharmacopœial names, unless they are exactly the standard prescribed by the pharmacopœia; it being usually considered in interpretation of such laws that when a pharmacist labels a substance with the pharmacopœial name, he means pharmacopœial strength. Thus to dispense essence of vanilla containing tonka bean, labeled "essence of vanilla," would be the ground for legal action.

No. 8 acetic acid is so called because one part of same with eight parts of water is supposed to give the strength of dilute vinegar. *Vinegar* is a 3 to 5 per cent. solution of acetic acid, more or less impure, and it is assumed that it is always made by the fermentation of alcoholic liquids. Thus a dilute white wine or cider, when fermented, will yield vinegar. A quick method for making vinegar is Schutzenbach's method; percolating diluted alcohol over oak shavings. Authorities state that by any of these methods no vinegar containing more than 15 per cent. acetic acid can be made, and as on the market there are a large number of so-called cider vinegars, as strong as 20 to 25 per cent., the conclusion is obvious that such are made from wood vinegar.

The commercial grading of vinegar is by the awkward denomination of so many "*grains*," and this means the number of grains of alkali necessary exactly to neutralize one ounce of the vinegar.

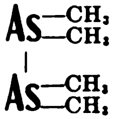
This is even more vague than the average commercial standard, as different authorities say the alkali is sodium carbonate, sodium bicarbonate, potassium carbonate, potassium bicarbonate respectively. Then it is uncertain whether the ounce means troy, avoirdupois, or fluid. If the alkali is potassium bicarbonate, and the "ounce" means fluidounce, "100-grain vinegar" should contain about 12 per cent. acetic acid; 50-grain should contain about 6 per cent. of acetic acid.

Acetic acid is interesting as one liquid of which the specific gravity is not a criterion of strength. Thus at 15° glacial acetic acid has a specific gravity of 1.0562; 85 per cent. has a specific gravity of 1.0747; 81 per cent. is 1.0755; 80 per cent. has a specific gravity of 1.0756, which same specific gravity is possessed by the 79 per cent., 78 per cent., and 77 per cent.; 76 per cent. has a specific gravity of 1.0755, and from that point on a gradual diminution of specific gravity occurs until 43 per cent. has a specific gravity of 1.056—the same specific gravity as the glacial.

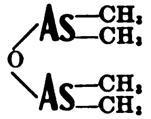
The high specific gravity exhibited by acid containing 77 per cent. to 80 per cent. CH_3COOH is supposed to be due to the formation, in the solution, of hydroxides of acetic acid.

The *tests* for acetic acid are as follows: When the acid (or an acetate), alcohol, and sulphuric acid are heated together, the mixture gives the pleasant odor of acetic ether. On the other hand, any acetate, when fused with arsenic trioxide on a platinum foil, gives the disgusting odor of cacodyl.

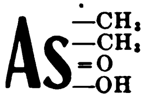
This substance is really a mixture of *cacodyl*, $As_2(CH_3)_4$, and *cacodyl oxide*, $As_2(CH_3)_4O$; the graphic formulas of the two bodies being respectively:



and



These substances, on treatment with mercuric oxide, yield *cacodylic acid* or dimethyl arsenic acid.



ACIDUM ACETICUM DILUTUM—Diluted Acetic Acid

(Acid. Acet. Dil.)

An aqueous solution containing not less than 5.7 nor more than 6.3 per cent. of $C_2H_4O_2$ or CH_3COOH (60.03).

Condensed Recipe.

Dilute acetic acid (36 per cent.) with enough distilled water to make a 6 per cent. product. For details see U.S.P., p. 7.

Summarized Description.

Miscible with water or alcohol; sp. gr. 1.008; in other respects, like acetic acid. For *assay* see U.S.P., p. 7 and also Part V of this book.

Assay.—Details in Part V.

Remarks.—Diluted acetic acid, contrary to the general rule for diluted acids (that they be 10 per cent.), contains 6 per cent. absolute acetic acid.

Dose.—2 mils (30 minims).

SODII CACODYLAS—Sodium Cacodylate

(Sod. Cacodyl.)

Sodium dimethylarsenate [$Na(CH_3)_2AsO_2$ = 160.01], with a somewhat variable amount of water of crystallization. It contains not less than 72 per cent. nor more than 75 per cent. of $Na(CH_3)_2AsO_2$. Preserve it in well-closed containers.

Summarized Description.

White, odorless, deliquescent prisms; or granular powder; soluble in about 0.5 part of water and in about 2 parts of alcohol; melts at 60°C.; anhydrous at 120°C., burns with a bluish flame having garlic-like odor. For details see U.S.P., p. 386.

For *tests for identity*, for *impurities:* monomethyl arsenate (no turbidity with calcium chloride). Arsenate or phosphate (no turbidity with magnesia mixture). Heavy metals, chloride, sulphate (usual tests) and for *assay* see U.S.P., p. 386 and also Part V of this book.

Remarks.—This new official substance is made by neutralizing cacodylic acid (prepared as suggested above) with sodium hydroxide. It is a white powder soluble in water, and is used as an alterative and tonic.

Dose.—60 milligrammes (1 grain).

ACIDUM TRICHLORACETICUM—Trichloracetic Acid

(Acid. Trichloracet.)

A monobasic organic acid. It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99 per cent. of $C_2HO_2Cl_3$ or $CCl_3.COOH$ (163.39). Preserve it in well-stoppered bottles in a cool place, protected from light.

Summarized Description.

Colorless, deliquescent, rhombohedral crystals; slight characteristic odor; very soluble in water, alcohol and ether; not more than $\frac{5}{100}$ of 1 per cent. of ash. For details see U.S.P., p. 28.

For *tests for identity*, for *impurities* (chlorides and nitric acid) and for *assay* see U.S.P., p. 28 and also Part V of this book.

Remarks.—As chloral represents aldehyde with three hydrogen atoms replaced by three chlorine atoms,

Aldehyde.	Chloral.
CH_3CHO	CCl_3CHO,

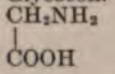
so the trichloracetic acid represents acetic acid with three hydrogen atoms replaced by three chlorine atoms, viz.:

Acetic acid.	Trichloracetic acid.
CH_3COOH	CCl_3COOH.

Again, as acetic acid can be made by the oxidation of aldehyde (see p. 573), so chloral hydrate on oxidation yields trichloracetic acid. Trichloracetic acid is used in dentistry for hardening the gums.

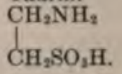
Glycocoll, or amidoacetic acid, and *taurin*, or amidoethylsulphuric acid, must be given passing notice as constituents of oxgall (p. 852). The graphic formulas of these two bodies are:

Glycocoll.



$$\begin{array}{l} CH_2NH_2 \\ | \\ COOH \end{array}$$

Taurin.

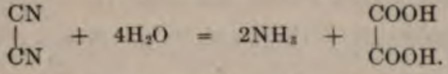


$$\begin{array}{l} CH_2NH_2 \\ | \\ CH_2SO_3H. \end{array}$$

The *polybasic acids* are derivatives of the hydrocarbons containing more than one carboxyl group. Thus an acid corresponding to the general formula $R^{II}(COOH)_2$, called dibasic acid, and $R^{III}(COOH)_3$, called tribasic acid, are both illustrations of polybasic acids. The simplest of these is the one which can be considered as derived from ethane.

Oxalic Acid $(COOH)_2$.—This body was long known in the past as the potassium oxalate, which is the constituent of the leaves of several plants, notably *Oxalis perennis*, from which the acid derives its name. It was Scheele, in 1776, who first gave the acid a thorough chemical examination.

Oxalic acid can be made synthetically by several methods. Thus cyanogen, when treated with water, forms ammonia and oxalic acid by the following reaction:



$$\begin{matrix} CN \\ | \\ CN \end{matrix} + 4H_2O = 2NH_3 + \begin{matrix} COOH \\ | \\ COOH. \end{matrix}$$

This is stated because it represents the real method of the synthesis of any acid, the same being formed from hydrocarbons containing one less carbon atom than the acid desired by converting same into chloride, then replacing the chlorine group by the cyanogen group (CN), and then converting the cyanogen group into the carboxyl group by the reaction given above, which is considered as a variety of saponification.

The commercial manufacture of oxalic acid is by the oxidation of either sugar or starch by nitric acid, or by fusing cellulose (sawdust) with potassium hydroxide. The latter is the popular method, the yield being 50 per cent. as much as the sawdust employed.

Oxalic acid is not official, although mentioned in the pharmacopœia as a test solution, both in qualitative testing and in volumetric analysis. It is poisonous, and its antidote is any convenient preparation of lime, thus forming insoluble calcium oxalate.

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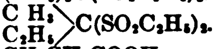
CHAPTER XXXVIII

DERIVATIVES OF PROPANE, BUTANE, AND PENTANE

PROPANE

THE propane derivatives of interest are:

Propyl alcohols	C_3H_7OH.
Propyl aldehyde	CH_3CH_2CHO.
Acetone, U.S.P.	$CH_3—CO—CH_3$.
Sulphonmethane, U.S.P.	$(CH_3)_2C(SO_2C_2H_5)_2$.
Sulphonethylmethane, U.S.P.	 $\begin{matrix}CH_3\\C_2H_5\end{matrix}\!\!>C(SO_2C_2H_5)_2$.
Propionic acid	CH_3CH_2COOH.
Lactic acid, U.S.P.	$CH_3CHOHCOOH$.
Glycerin, U.S.P.	$C_3H_5(OH)_3$.
Nitroglycerin	$C_3H_5(ONO_2)_3$. (Official in *spirit of glyceryl nitrate.*)
Olein	Glyceryl oleate and other fats.
Glycerophosphoric acid	$C_3H_5(OH)_2PO_4H_2$. (Sodium and calcium salts official.)

Of the above, the alcohols have no pharmaceutic interest, it being necessary only to call attention to the fact that two isomeric forms of propyl alcohol are known—the primary and the secondary.

The former yields on oxidation propylic aldehyde, while the secondary gives, under the same treatment, the ketone, acetone. Both of these alcohols yield, with the appropriate acids, esters.

Propionic aldehyde can be dismissed on the simple statement that it, on oxidation, yields propionic acid, CH_3CH_2COOH.

ACETONUM—Acetone

(**Aceton.**—Dimethyl-ketone)

A liquid containing not less than 99 per cent. by weight of C_3H_6O or $CH_3.CO.CH_3$ (58.05). Preserve it in well-closed containers in a cool place, remote from fire.

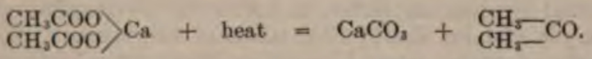
Summarized Description.

Colorless, mobile, volatile liquid; characteristic ethereal odor; pungent sweetish taste; sp. gr. 0.790; miscible with water, alcohol, ether, chloroform and most volatile oils; boils at 56° to 58°C.; inflammable, burning with a non-sooty flame. For details see U.S.P., p. 4.

For *tests for identity*, for *impurities;* empyreumatic substances (does not decolorize permanganate solution) and for *assay* see U.S.P., p. 4 and also Part V of this book.

Remarks.—Acetone is the first representative of the ketones (p. 573) to be studied. It has been long known as one of the products of the destructive distillation of wood. It was not, however, until 1832 that its chemical composition became known through the investigations of Liebig.

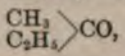
Acetone has been secured from natural sources (the urine and the blood). It can be made by oxidation of secondary propyl alcohol, as already explained on p. 573. Another chemical method of the manufacture of acetone is by the destructive distillation of calcium acetate by the following reaction:



$$\left.\begin{matrix}CH_3COO\\CH_3COO\end{matrix}\right>Ca + \text{heat} = CaCO_3 + \begin{matrix}CH_3-\\CH_3-\end{matrix}CO.$$

This method is of importance, inasmuch as it is the type of the general manufacture of ketones.

As seen above, calcium acetate yields dimethyl ketone or acetone. If, instead of calcium acetate, a mixture of calcium acetate and calcium propionate be distilled, we get methyl-ethyl-ketone,



$$\left.\begin{matrix}CH_3\\C_2H_5\end{matrix}\right>CO,$$

while a mixture of calcium acetate and calcium benzoate gives methyl-phenyl-ketone. In the Squibb process, acetone is made by passing alcohol through rotating tubes heated to about 500°C. The commercial source of acetone, however, is from the destructive distillation of wood, and the acetone is extracted from the distillate, as has already been explained on p. 584.

Acetone possesses, in common with all ketones, a number of characteristic reactions; thus it forms crystalline compounds with ammonium bodies, or with potassium bisulphate, and, most striking of all, when treated with hydroxylamine, it forms characteristic bodies called "oximes" (RNOH). It also forms distinct crystalline bodies with phenyl hydrazine, the reagent giving practically similar results with aldehydes. In truth, the two great classes, aldehydes and ketones, are difficult to distinguish from each other, about the only point of difference being that, while aldehydes oxidize the acids, ketones break up into simpler bodies on oxidation.

The reactions above cited are of pharmaceutic interest only inasmuch as hydroxylamine and phenylhydrazine give distinct crystalline bodies with the sugar (these substances being either of aldehyde or ketone character), hence these reagents are used for testing sugars.

Acetone has but little medical value, its chief use in pharmacy being as a solvent. For this purpose it is used in making the official oleoresins. It yields several products of marked value in medicine, two of which are now official.

SULPHONMETHANUM—Sulphonmethane

(Sulphonmeth.—Sulphonal)

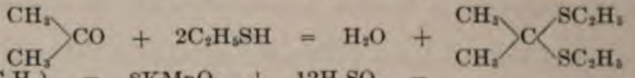
Diethylsulphonedimethylmethane [$C_7H_{16}S_2O_4$ or $(CH_3)_2C(SO_2C_2H_5)_2$ = 228.27]. Preserve it in well-closed containers.

Summarized Description.

Colorless, inodorous, nearly tasteless prismatic crystals or a powder; soluble in about 360 parts of water, in about 47 parts of alcohol; also soluble in chloroform and ether; melts between 124° and 126°C. For details see U.S.P., p. 418.

For *tests for identity*, for *impurities* see sulphonethylmethane.

Remarks.—This substance, commonly called *sulphonal*, is made by treating acetone with ethyl mercaptan and oxidizing the resulting mercaptid with potassium permanganate, the equation being as follows:



$$(CH_3)_2CO + 2C_2H_5SH = H_2O + (CH_3)_2C(SC_2H_5)_2$$

$$5(CH_3)_2C(SC_2H_5)_2 = 8KMnO_4 + 12H_2SO_4 = 5(CH_3)_2C(SO_2C_2H_5)_2 + 4K_2SO_4 + 8MnSO_4 + 12H_2O.$$

Mercaptan is a liquid of very disagreeable odor, made by treating ethyl bromide with potassium sulphydrate. It can easily be produced from sulphonal by heating same in a test-tube with charcoal, and this affords a simple test for the identification of sulphonal.

Sulphonal is a white, crystalline solid, sparingly soluble in water, and melting at 125°C. It is a valuable hypnotic.

Dose.—750 milligrammes (12 grains).

SULPHONETHYLMETHANUM—Sulphonethylmethane

(Sulphonethylmeth.—Trional)

Diethylsulphonemethylethylmethane [$C_8H_{18}S_2O_4$ or $(CH_3)(C_2H_5)C(SO_2C_2H_5)_2$ = 242.28]. Preserve it in well-closed containers.

Summarized Description.

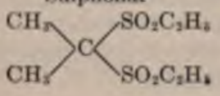
Colorless, lustrous, odorless crystalline scales; bitter in aqueous solution; soluble in about 200 parts of water; also soluble in alcohol or ether; melts between 74° and 76°C.; at higher heat decomposes. For details see U.S.P., p. 418.

For *tests for identity*, for *impurities:* Sulphates (barium chloride test). Chloride (silver nitrate test). Oxidizable matter (does not readily decolorize permanganate solution) see U.S.P., p. 418 and also Part V of this book.

Remarks.—This body, introduced under the name *trional*, differs from sulphonal by having an ethyl group in place of one of the methyl groups of sulphonal, as is shown below. It thus contains three ethyl groups, hence the name, trional. It is made like sulphonal, except that in place of acetone, ethyl methyl ketone is employed.

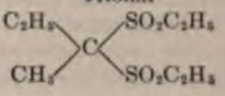
Tetronal contains no methyl group, but four ethyls (see compared formulas given below), and it is made like sulphonal, only that diethyl ketone is used in its manufacture instead of acetone (dimethyl ketone). Both trional and tetronal are used as hypnotics in 12-grain doses.

Sulphonal



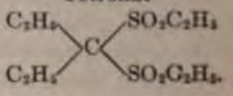
$$(CH_3)_2C(SO_2C_2H_5)_2$$

Trional



$$(C_2H_5)(CH_3)C(SO_2C_2H_5)_2$$

Tetronal



$$(C_2H_5)_2C(SO_2C_2H_5)_2.$$

Propionic acid (C_2H_5COOH), discovered by Gottlieb in 1844, can be made by oxidation of primary propionic alcohol, as above stated, and also by the saponification of ethyl nitrile, CH_3CH_2CN. It has no pharmaceutic value, but its derivative, oxypropionic acid, is official under the name of **lactic acid.**

Three oxypropionic acids are known: Ethylidene lactic acid, CH_3-CHOH-COOH; ethylene lactic acid, $CH_2OH—CH_2—COOH$; and sarcolactic acid. The official acid is the one first mentioned.

ACIDUM LACTICUM—Lactic Acid

(Acid. Lact.)

A liquid containing lactic acid [optically inactive alphahydroxypropionic acid, $C_3H_6O_3$ or $CH_3CHOHCOOH = 90.05$] and lactic anhydrides, equivalent to a total of not less than 85 per cent. nor more than 90 per cent. of $C_3H_6O_3$.

Summarized Description.

Colorless, hygroscopic, syrupy liquid; acid taste; miscible with water, alcohol or ether; insoluble in chloroform, petroleum benzin or carbon disulphide; sp. gr. 1.206; below 160°C. not vaporized, above 160° emits inflammable vapors. For details see U.S.P., p. 17.

For *tests for identity*, for *impurities:* Glycerin (not turbid on shaking with ether). Sugars (does not reduce Fehling's solution). Organic matter (no dark zone when layered on sulphuric acid). Sarcolactic acid (no change on adding copper sulphate solution). Chloride, sulphate, heavy metals, phosphoric, tartaric, citric and oxalic acids (usual tests). For details see U.S.P., p. 17 and also Part V of this book.

Remarks.—This body was discovered by Scheele in 1780 as a constituent of sour milk. Besides in milk, it is found in minute traces in opium, and also is found in gastric juice in that form of dyspepsia we call "sour stomach." It can be made synthetically in several ways, but it is of interest merely as establishing the fact that it is a derivative of propionic acid, the commercial source of manufacture being from sour milk.

Milk is a fluid obtained from the cow, and consists of fat (butter), emulsified by means of casein. This emulsion is considerably diluted with water, containing a variety of sugar called sugar of milk.

This sugar of milk, under the influence of certain bacteria found in the air, ferments to lactic acid. The actual method of production from milk is first by removing the butter in churning, then separating the casein by the addition of acid. The liquid remaining after the curd has been removed is called the *whey*, and contains the sugar of milk. If this whey is concentrated and allowed to stand, the milk sugar crystallizes (p. 628), but if the same is allowed to stand until fermentation sets in, lactic acid continues to form until the solution contains 1.6 per cent. acid, when the ferment becomes inactive. If the acidity of the mixture is lessened by treatment with zinc carbonate or chalk, the fermentation continues and the addition of alkali is carried on in actual practice in order to obtain a larger percentage of the acid. Of course, the finished product in such cases is either zinc or calcium lactate, but the acid can be easily freed from the metal by treatment with sulphuric acid. Lactic acid is now being made commercially by fermentation of glucose by the lactic acid ferment.

Lactic acid is a thick, syrupy liquid, of specific gravity 1.206. It always contains water, the strength of the official acid being from 85 to 90 per cent. By removing all the water a new body, *lactone*, is formed.

Dose.—Of lactic acid 2 mils (30 minims).

SYRUPUS CALCII LACTOPHOSPHATIS—Syrup of Calcium Lactophosphate

This official is made by mixing 25 grammes of precipitated calcium carbonate with 60 mils lactic acid, previously diluted with 100 mils water, whereby a solution of calcium lactate is obtained. To this is added 36 mils phosphoric acid, diluted with 50 mils water, and the mixture triturated until a perfect solution results. After adding 100 mils water the liquid is filtered and to the filtrate 50 mils of orange flower water is added, and 650 Gm. sugar dissolved therein by cold agitation. Then add enough water to make 1000 mils.

It is used as a nutritive tonic in wasting diseases.

Dose.—10 mils (2½ fluidrachms).

Polyatomic alcohols are those containing more than one hydroxyl group. Thus while alcohol, C_2H_5OH, containing one hydroxyl, is monatomic, glycol being $C_2H_4(OH)_2$, is diatomic, and glycerin, $C_3H_5(OH)_3$, is triatomic; hence the last two are polyatomic alcohols.

GLYCERINUM—Glycerin

(**Glycerin.**—Glycerol)

A liquid obtained by the hydrolysis of vegetable or animal fats, or fixed oils, purified by distillation, and containing not less than 95 per cent. of the trihydric alcohol $C_3H_5(OH)_3$ or $CH_2OH{\cdot}CHOH{\cdot}CH_2OH$ (92.06). Preserve it in well-closed containers.

Summarized Description.

Clear, colorless liquid of thick syrupy consistence; slight odor; sweet and then warm taste; miscible with water and alcohol; insoluble in chloroform, ether, benzene, petroleum benzin, carbon disulphide, fixed and volatile oils; sp. gr. about 1.249; volatilizes when concentrated at 100°C. For details see U.S.P., p. 203.

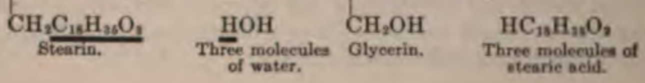
For *tests for identity*, for *impurities:* Carbonizable matters (does not color sulphuric acid). Fatty acids and esters (form of volumetric test). Acrolein and glucose (does not turn yellow with potassium hydroxide solution). Excess of chlorides (a modified volumetric test). Ammonium, sulphuric and oxalic acids, heavy metals, arsenic (usual tests) see U.S.P., p. 203 and also Part V of this book.

Remarks.—This interesting body was discovered by Scheele in 1789 in the wash-water in making lead-plaster. It was first analyzed by Pelouze in 1837, while its structural formula was worked out by Wuertz (1855). Its introduction as a commercial commodity was between 1844 and 1850, during which time it was introduced by Price, of England, Sarg, of Vienna, and Robert Shoemaker, of Philadelphia.

Glycerin has been made synthetically and by several methods, none of which is of interest save as establishing the structural formula assigned above. It is obtained commercially from fats, these being derivatives of glycerin with oleic, stearic, and palmitic acids (p. 653).

If a fatty oil, such as olive oil, be treated with lead oxide in the manufacture of lead plaster, a double decomposition occurs, with the formation of lead oleate and the freeing of glyceryl hydroxide, as fully explained on p. 1004, and this was the original method of the manufacture of glycerin.

In 1854 Tilgman found that glycerin could be obtained from the fats by treating same with superheated steam, and this is the method generally applied at present, the reaction being:



$$\begin{array}{lcccccc} CH_2\underline{C_{18}H_{35}O_2} & & \underline{H}OH & & CH_2OH & & HC_{18}H_{35}O_2 \\ | & & & & | & & \\ CH\,\underline{C_{18}H_{35}O_2} & + & \underline{H}OH & = & CHOH & + & HC_{18}H_{35}O_2 \\ | & & & & | & & \\ CH_2\underline{C_{18}H_{35}O_2} & & \underline{H}OH & & CH_2OH & & HC_{18}H_{35}O_2 \\ \text{Stearin.} & & \text{Three molecules of water.} & & \text{Glycerin.} & & \text{Three molecules of stearic acid.} \end{array}$$

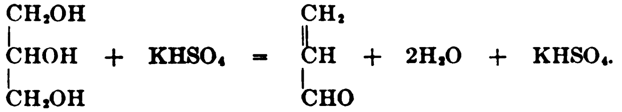
This saponification can also be accomplished by treating the fat with diluted sulphuric acid in the presence of a catalytic agent, such as sulphonated benzene.

Crude glycerin thus obtained has to be purified by distillation in vacuo, although it is said that the chemically pure product can be distilled without decomposition at ordinary atmospheric pressure.

Glycerin is a transparent, viscid liquid, of sweetish taste, of specific gravity 1.25. As already mentioned, glycerin is a solvent of peculiar value, inasmuch as it is also antiseptic; it is used medicinally as a protective in the form of *carbolated glycerin* (glycerite of phenol, U.S.P.), and when used in the form of glycerin suppositories, it acts as a purgative. Glycerin is also much esteemed as an ingredient of domestic cough remedies.

Dose.—4 mils (1 fluidrachm).

Glycerin, when treated with oxalic acid, yields formic acid and when treated with potassium bisulphate, yields acrolein by the following reaction:

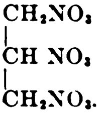


$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + KHSO_4 = \begin{array}{l} CH_2 \\ \| \\ CH \\ | \\ CHO \end{array} + 2H_2O + KHSO_4.$$

Acrolein is the aldehyde of allyl alcohol, has a very disagreeable odor, and is very irritating to the eyes and throat. It is familiar as the disagreeable odor of burning fat.

Nitroglycerin.—This ester of glycerin was discovered by Sobrero in 1847. It is made by placing glycerin in a freezing mixture and allowing a mixture of nitric acid and sulphuric acid to drip down upon it, cautiously stirring the finished product and then diluting.

Like stearin and olein, nitroglycerin is an ester of glycerin. On p. 653 is given the graphic formula of olein and of stearin; to these we will add, for comparison, the graphic formula of nitroglycerin:



$$\begin{array}{l} CH_2NO_3 \\ | \\ CH\ NO_3 \\ | \\ CH_2NO_3. \end{array}$$

Reference to p. 594 will show that the ester, ethyl nitrite, $C_2H_5NO_2$, was made by treating grain alcohol—ethyl hydroxide, C_2H_5OH—with nitrous acid, by the following reaction:

$$C_2H_5OH + HNO_2 = H_2O + C_2H_5NO_2.$$

Even so, the ester, nitroglycerin, $C_3H_5(NO_3)_3$, is made by treating the alcohol, glyceryl hydroxide—glycerin, $C_3H_5(OH)_3$—with nitric acid, HNO_3, by the following reaction:

$$C_3H_5(OH)_3 + 3HNO_3 = 3H_2O + C_3H_5(NO_3)_3,$$

sulphuric acid being used as the dehydrating agent (p. 595).

Nitroglycerin in concentrated form is used as an explosive, it being one of the most rapid and dangerous of known explosives. As explained on p. 423, an explosive is a body which, under appropriate treatment, will rapidly be converted into a large amount of gas or vapor, and under this test nitroglycerin is one of the most powerful, since one volume of nitroglycerin will, on explosion, yield 713 volumes of gas, while one volume of gunpowder yields only 280 volumes of gas.

Nitroglycerin, while so valuable an explosive, possesses an element of safety, inasmuch as it is not easily set off, it being exploded only by being rapidly heated or by concussion, and in order to obtain the best results the latter method is usually employed, the charge of nitroglycerin being placed in contact with a cap of fulminating mercury, which is fired either by a fuse or by electric connection.

The liquid form of nitroglycerin being inconvenient in many cases, explosive modifications of a solid character have been devised. Thus, *dynamite* is a mixture of one part of infusorial earth with three parts of nitroglycerin.

Nitroglycerin, like all esters, can be saponified by alkali. Thus we have already found that ethyl nitrite, when treated with potassa, is converted into alcohol and potassium nitrite, so in the same way nitroglycerin treated with potassium hydroxide yields inert glycerin and equally harmless potassium nitrate by the following reaction:

$$C_3H_5(ONO_2)_3 \ + \ 3KOH \ = \ C_3H_5(OH)_3 \ + \ 3KNO_3.$$

This gives a hint as to avoiding explosion if nitroglycerin or its spirit is accidentally spilled.

SPIRITUS GLYCERYLIS NITRATIS—Spirit of Glyceryl Trinitrate

(Sp. Glyceryl. Nit.—Spirit of Glonoin—Spirit of Nitroglycerin)

An alcoholic solution containing not less than 1 per cent. nor more than 1.1 per cent. of $C_3H_5(NO_3)_3$ (227.07). Preserve it in well-stoppered bottles in a cool, dark place, remote from fire.

Great care must be exercised in dispensing, handling, packing, transporting, and storing this Spirit, since a dangerous explosion may result if any considerable quantity of it is spilled, and the alcohol wholly or partly lost by evaporation. If, through accident, it is spilled, a solution of potassium hydroxide must be poured over it at once to effect partial decomposition.

Summarized Description.

Clear, colorless liquid; alcohol odor; very toxic, hence taste with caution; sp. gr. 0.814 to 0.820. For other tests see U.S.P., p. 407.

Remarks.—This official is a 1 per cent. alcoholic solution of nitroglycerin. It is a colorless liquid, of alcoholic taste. The pharmacopœia, however, gives warning that utmost care must be exercised when tasting, as even a small quantity is liable to produce violent headache. It is also well to heed the pharmacopœial warning that the spirit must be handled with the utmost caution, for if spilled, the alcohol will evaporate and the explosive properties of the nitroglycerin will be exerted. Note that the pharmacopœia directs that the danger of explosion is lessened by adding solution of potassa to the spot.

Spirit of nitroglycerin is used as a heart stimulant.

Dose.—0.05 mil (1 minim).

Glyceryl-phosphoric Acid.—In 1845, Gobley discovered in yolk of egg a substance which proved to be a compound of glycerin and phosphoric acid; the structure of which is supposed to be $CH_2OPO(OH)_2$—$CHOH$—CH_2OH. An isomere of this substance where the phosphoric acid radicle is attached to central carbon atom of the glycerin structure is also known. Both of these acids form salts and combinations of these, with calcium glycerophosphate as leading ingredient have become quite popular. At present glycerophosphoric acid is made by the condensation of the two ingredients.

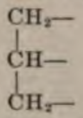
The present pharmacopœia recognizes *sodium glycerophosphate* (p. 436), and *calcium glycerophosphate* (p. 473).

Boroglycerin, $C_3H_5BO_3$, is the boric acid ester of glycerin, and is made by heating glycerin with boric acid. For details of operation see Glycerite of Boroglycerin, U.S.P. (p. 211). The official glycerite can be considered as a 50 per cent. solution of boroglycerin, as the following calculation shows:

$$\text{Reaction: } \underset{92}{C_3H_5(OH)_3} + \underset{62}{H_3BO_3} = \underset{54}{3H_2O} + \underset{100}{C_3H_5BO_3}.$$

From the molecular weight just given it is seen that 62 Gm. boric acid plus 92 Gm. glycerin give 100 Gm. boroglycerin, and as the pharmacopœial recipe (given on p. 211) directs 310 Gm. boric acid plus 460 Gm. glycerin, that this be heated until 500 Gm. remain, and that this be mixed with 500 Gm. glycerin, it is plain that the above quantities (five times the theoretic amounts) will yield 500 Gm. boroglycerin, and that, therefore, the finished glycerite contains 50 per cent. boroglycerin. This is important, inasmuch as boroglycerin is frequently prescribed in 10 per cent., 20 per cent., or 30 per cent. solution, and such should be made by properly diluting the official glycerite with glycerin.

Fats are esters of glycerin with oleic, stearic, and palmitic acids. They will be considered in a special chapter as derivatives of the acids just mentioned. As mentioned above, the radicle—



$$\begin{array}{l} CH_2- \\ | \\ CH- \\ | \\ CH_2- \end{array}$$

found in glycerin is called *glyceryl*. This is not to be confused with another radicle (C_3H_5) having the formula $CH_2 = CH—CH_2$, called *allyl*. Allyl is an unsaturated radicle, and, therefore, possesses but one free bond, while glyceryl is a saturated radicle and has three free bonds. Three compounds of allyl are worth passing notice: *acrolein* (allyl aldehyde), $CH_2 = CH—CHO$, just described as one of the products obtained on strongly heating glycerin; allyl sulphide, $(CH_2 = CH—CH_2)_2S$, the odorous constituent of oil of garlic; and, lastly, allyl isothiocyanate (oil of mustard), which will be considered among the cyanogen derivatives (p. 674).

BUTANE

(C_4H_{10})

The butane derivatives of general importance are:

The butyl alcohols	C_4H_9OH.
Butyl chloral hydrate	$CCl_3CH_2CH_2CHO + H_2O$.
Butyric acids	$CH_3CH_2CH_2COOH$, etc.
Succinic acid	$C_2H_4(COOH)_2$.
Malic acid	$C_2H_3(OH)(COOH)_2$.
Tartaric acid, U.S.P.	$C_2H_2(OH)_2(COOH)_2$.

The haloid derivatives of butane are of no pharmaceutic interest. Butyl alcohols, C_4H_9OH, are found in four forms, for it will be noticed on p. 576 the number of isomeres increase in proportion to the number of carbon atoms in a compound.

Of these butyl alcohols, the primary $CH_3CH_2CH_2CH_2OH$ is of interest as being one of the constituents of crude fusel oil. On oxidation the primary alcohol yields butyric aldehyde, and then the oxidation product of butyric aldehyde, butyric acid.

Tertiary butyl alcohol, $(CH_3)_3COH$, is of interest because its trichlor-derivative—$(CH_3)_2CCl_3COH$—is being considerably advertised under the names *chloretone* or *chlorbutanol*. It is made by treating a mixture of chloroform and acetone with caustic alkalis, and is a white crystalline solid, soluble in 125 parts of water, very soluble in alcohol. It is used as a hypnotic in doses of 5 to 20 grains.

Brometone, $(CH_3)_2CBr_3COH$, has been obtained in white crystals melting at 167°C.

A derivative of butyric aldehyde ($CH_3CH_2CH_2CHO$) is ***butyl chloral hydrate*** ($CCl_3CH_2CH_2CHO + H_2O$), which was discovered by Kraemer and Pinner in 1870, who, on its discovery, thought it was the isomeric "*croton chloral hydrate*," and under this name the product was introduced into commerce as a hypnotic. *Dose.*—0.3 to 0.6 Gm. (5 to 10 grains).

Two *butyric acids* are known: (1) $CH_3CH_2CH_2COOH$ (normal)
(2) $(CH_3)_2CHCOOH$ (iso).

The first of these is a constituent of sweat, while its glycerin ester comprises 2 to 3 per cent. of butter. From its discovery in butter the name, butyric acid, is obtained.

Butyric ether is the ester of butyric acid made by treating it with ethyl alcohol in the presence of a dehydrating agent. It is a colorless liquid of fruity odor boiling at 121°C., that is used largely in making artificial fruit essences.

Banana oil is a mixture of butyric ether, 1 part; amyl acetate, 1 part, and alcohol 5 parts. It is used largely as a solvent in the gilding industry.

Succinic acid,

$$COOH—CH_2—CH_2—COOH$$

can be considered as butyric acid in which the end methyl group is converted into carboxyl. It occurs naturally in amber (*succinum*), hence its name, and is also found in certain fruit-juices.

Succinic acid is a white, crystalline body, used in medicine to a certain extent for rheumatism and bronchitis.

Dose.—0.3 to 1.0 Gm. (5 to 15 grains).

Malic acid,

$$COOH—CHOH—CH_2—COOH$$

can be considered as monoxysuccinic acid, that is, succinic acid in which one hydrogen is replaced by hydroxyl. Malic acid was discovered in apples, *Pyrus Malus*, by Scheele in 1785, and can be made synthetically from succinic acid. An amido derivative of succinic acid is ***asparagin***,

$$CONH_2—CHNH_2—CH_2COOH$$

which is found in many plants.

Malate of iron is sometimes used as a tonic. It is a constituent of *ferrated extract of apples* N.F. (p. 281) which is made by treating reduced iron with fresh apple juice and then evaporating the resulting solution of crude ferrous malate to a pilular extract.

Tartaric acid,

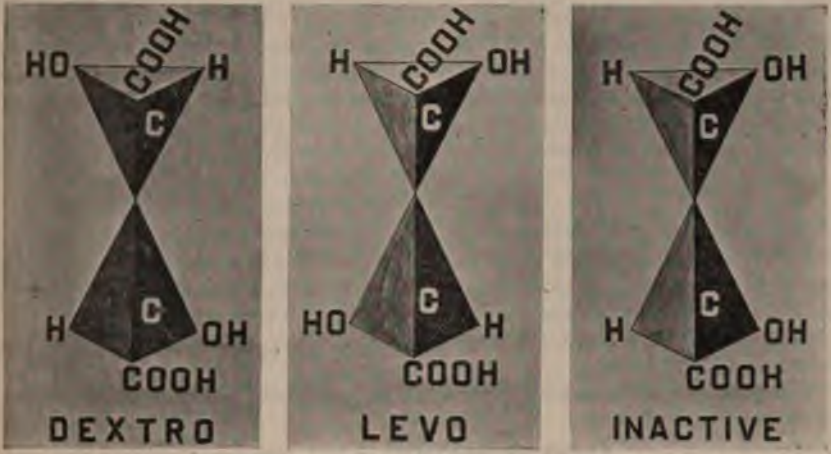
$$COOH—CHOH—CHOH—COOH$$

is dioxysuccinic acid, and was found by Scheele in 1769 in cream of tartar. It is interesting as being found in four distinct varieties, and more striking is that all of them seem to have the same graphic formula. The difference among these tartaric acids is chiefly their behavior toward polarized light, the one rotating the ray to the right, hence called dextrogyre, another rotating light to the left, or levogyre; a third does not deviate the ray of light at all, hence called inactive, and the fourth modification, which is also inactive, is racemic acid.

The experiments of the three tartaric acids first mentioned, performed by Pasteur, have become classic, as constituting foundations of the theory of Van t'Hoff ("Chemistry in Space").

Pasteur proved that the crystals of the dextrogyre tartaric acid and of the levogyre tartaric acid differ from each other only in the fact that one is the exact mirror picture of the other. He also proved that the inactive was a mixture of equal quantities of dextrogyre and levogyre tartaric acids.

Van t'Hoff took up the study of the tartaric acids as opening a new field of thought. Up to this time chemical formulas were considered as simply pictures on flat surfaces, while his efforts were directed to attempt to show the exact location of the constituent atoms in a molecule, as to length, breadth, and thickness. It is, of course, far beyond the scope of this work to give any details of this fascinating theory, and the reader is, therefore, referred to Van t'Hoff's book. Suffice it to say that Van t'Hoff's theory is that the real difference among the three tartaric acids is merely the relative difference between the position of the hydrogen, hydroxyl, and carboxyl which they contain, and he gives the following pictures of these three interesting bodies:



a b c

Fig. 241.—Tartaric Acid Formulas. *a*, Dextrogyrate; *b*, Levogyrate; *c*, Inactive.

He also discovered a very interesting fact in regard to these bodies, namely, that each bond of the two central carbon atoms of the above pictures is attached to a different atomic grouping; thus one bond is attached to the other central carbon atom, another to a carboxyl, a third to a hydrogen, and a fourth to a hydroxyl. A carbon atom in which each bond is attached to different groups is called an *asymmetric carbon atom*, and is a constituent of all organic bodies which polarize light. This important statement was made about thirty-three years ago, and not only has never been disproved, but is now accepted as a fact. To understand this very striking chapter of newer chemistry thoroughly, a knowledge of polarization is essential, and as this is plainly beyond the limits of the present volume, the reader is advised to study the question in some standard work of physics.

ACIDUM TARTARICUM—Tartaric Acid

(Acid. Tart.)

A dibasic organic acid usually obtained from wine lees or argol. It contains not less than 99.5 per cent. of $C_4H_6O_6$ or $C_2H_2(OH)_2(COOH)_2$ (150.05).

Summarized Description.

Colorless, translucent, monoclinic prisms or fine white powder; acid taste; soluble in about 0.75 part of water, and in about 2.7 parts of alcohol; not more than $\frac{5}{100}$ of 1 per cent. of ash. For details see U.S.P., p. 27.

For *tests for identity*, for *impurities* (sulphuric and oxalic acids, lead, heavy metals) and for *assay* see U.S.P., p. 27 and also Part V of this book.

Remarks.—The official tartaric acid, which is the dextrogyrate variety, occurs in the juice of grapes and in other fruit in the form of acid potassium tartrate and calcium tartrate, its commercial source being from *argol*, which represents the acid potassium tartrate which deposits from wine during the process of aging. The crude tartar of argol is cooked with chalk, thus forming calcium tartrate, which is then heated with sulphuric acid, forming insoluble calcium sulphate and soluble tartaric acid. A solution of the latter is then evaporated and crystallized.

Tartaric acid is used as a refrigerant, especially in the form of potassium bitartrate. The acid is a constituent of the official Seidlitz powders and is interesting by reason of its ability to form three distinct classes of salts—normal, acid, and double. (See p. 362.)

Dose.—500 milligrammes (8 grains.)

PENTANE

(C_5H_{12})

The pentane derivatives of pharmaceutic interest are:

Amyl alcohols	$C_5H_{11}OH$.
Amyl nitrite, U.S.P.	$C_5H_{11}NO_2$.
Valerianic aldehyde	C_4H_9CHO.
Valerianic acids	C_4H_9COOH.

The halogen derivatives of pentane are of no pharmaceutic interest. The monatomic alcohols of pentane are not called pentyl alcohols, but go by the name of amyl alcohols, being so called because found abundantly in the spirit obtained by fermenting starch (amylum).

The amyl alcohols, $C_5H_{11}OH$ are interesting as being the chief constituents of fusel oil.

There are eight isomeric forms of amyl alcohols possible, and of these, seven are known.

AMYLIS NITRIS—Amyl Nitrite

(Amyl. Nitris)

A liquid containing not less than 80 per cent. of $C_5H_{11}NO_2$ (117.10) (chiefly isoamyl nitrite). Preserve it in hermetically sealed glass bulbs, or in glass-stoppered vials, in a cool place, protected from light.

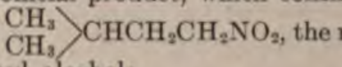
Summarized Description.

Clear yellowish liquid; ethereal fruity odor; pungent aromatic taste; almost insoluble in water; miscible with alcohol or ether; sp. gr. 0.865 to 0.875; very volatile; inflammable, burning with a yellow sooty flame. For details see U.S.P., p. 48.

For *tests for identity,* for *impurities:* Free acid (a modified volumetric test). Aldehyde (does not darken ammoniacal silver nitrate solution) see U.S.P., p. 48 and also Part V of this book.

Assay.—Details identical with assay for spirit of nitrous ether (p. 594) except that factor is $\frac{\text{volume gas} \times 4.8}{\text{weight of nitrite used.}}$

Remarks.—This ester, which is quite similar to ethyl nitrite (p. 594), is made by practically the same process as the former, namely, by treating amyl alcohol with potassium nitrite and sulphuric acid, and distilling over the reaction products.

It can also be made by treating fusel oil or amyl alcohol with nitric acid and copper, the copper reducing the nitric acid to the nitrous form. This yields the official product, which consists of about 80 per cent. of iso-amyl nitrite,  $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CHCH_2CH_2NO_2$, the rest being mixture of nitrites of the other amyl alcohols.

Amyl nitrite is a limpid, light yellow liquid, of pleasant but striking odor, and sharp taste. While it boils at 96° to 99°C., it is very volatile at ordinary temperatures, hence the preservation of amyl nitrite calls for considerable care, and the best form in which it can be put up is in sealed glass tubes rather than in glass-stoppered bottles.

Not merely is loss experienced in amyl nitrite by evaporation, but also by reason of the fact that in presence of moisture it decomposes into amyl alcohol and nitrous acid by the following reaction.

$$C_5H_{11}NO_2 + H_2O = C_5H_{11}OH + HNO_2;$$

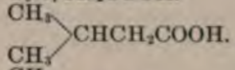
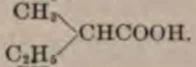
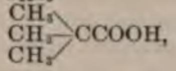
hence in order to preserve amyl nitrite, it is necessary that it be kept absolutely dry.

Amyl nitrite is a very valuable medicine, because it furnishes a specific in cases of suffocation resulting from attacks of angina pectoris. When sharp spells of this distressing complaint come on, the inhalation of amyl nitrite usually gives relief. Amyl nitrite is put up for this purpose in "*pearls*," that is, in small hollow shells of thin glass hermetically sealed. When the attack begins, the patient crushes one of these pearls in a handkerchief and inhales the escaping vapor.

Dose.—By inhalation, 3 decimils (3 minims).

The primary amyl alcohol on oxidation yields valerianic aldehyde, and this in turn yields valerianic acid. Secondary amyl alcohols, on the other hand, yield on oxidation either diethyl-ketone, $\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right>CO$, or methyl propyl ketone, $\left.\begin{matrix}CH_3\\C_3H_7\end{matrix}\right>CO$.

Valeric Acid (C_4H_9COOH).—Four modifications of valeric acid are known:

Propyl acetic acid,	$C_3H_7CH_2COOH$.
Isopropyl acetic acid,	 $\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right>CHCH_2COOH$.
Methyl ethyl acetic acid,	 $\left.\begin{matrix}CH_3\\C_2H_5\end{matrix}\right>CHCOOH$.
Trimethyl acetic acid,	 $\left.\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\right>CCOOH$,

and of these, the one usually found in commerce is the isopropyl acetic acid, this body being recognized in pharmacy as *acidum valerianicum.*

Valerianic acid is a constituent of some animal fluids, such as sweat. It is also found in the form of esters in dolphin fat, but the chief natural origin of valerianic acid, from which it obtains its name, was from valerian root, from which it is obtained by distillation with water.

Usually, however, it is made by the oxidation of the appropriate amyl alcohol with potassium dichromate and sulphuric acid.

Valerianic acid is a mobile, oily liquid, boiling at 175°C., of specific gravity 0.935, having the characteristic odor of valerian. It combines with alkalis to form salts, such as the valerianates of ammonium, iron, and zinc, each of which is discussed under its respective metal, hence it is only necessary here to cite that, in order to get a white crystalline sample of ammonium valerianate, monohydrated valerianic acid must be used, and not the trihydrated frequently found in commerce. The trihydrated can be converted into the monohydrated by crystallizing a mixture of neutral sodium valerianate with the crude acid, and treating the crystalline acid salt with concentrated sulphuric acid.

Valine is alpha-amino-isovaleric acid, $(CH_3)_2CHCH(NH_2)COOH$. It is an active constituent of ergot. (See p. 837.)

While tricarballylic acid, citric acid, and aconitic acid are derivatives of hexane, they can be most conveniently discussed in this chapter, leaving the next chapter for the sole consideration of those very important hexane derivatives, the carbohydrates.

Tricarballylic Acid ($C_3H_5(COOH)_3$).—This acid with the long name is cited not because of its pharmaceutic value, but merely because it is the connecting link between the compounds just mentioned and of the important organic acid which will be cited next. It will be seen, from the formula given below, that this represents that acid of hexane containing three carboxyls, and which, therefore, may be considered as the oxidation product of primary triatomic hexyl alcohol. It, therefore, serves the purpose of introducing its oxy-derivative, which is none other than *citric acid*, $C_3H_4OH(COOH)_3$.

ACIDUM CITRICUM—Citric Acid

(Acid. Cit.)

A tribasic organic acid usually obtained from the juice of limes or lemons. It contains not less than 99.5 per cent. of $C_6H_8O_7 + H_2O$ or $C_3H_4(OH)(COOH)_3 + H_2O$ (210.08). Preserve it in well-closed containers.

Summarized Description.

Colorless, translucent, right-rhombic prisms or white powder; soluble in about 0.5 part of water, in about 1.5 parts of alcohol and in 21 parts of ether. For details see U.S.P., p. 9.

For *tests for identity*, for *impurities:* Tartaric acid (no odor of burnt sugar on ignition; does not color sulphuric acid more than yellow). Oxalic acid (the calcium test). Sulphuric acid and lead (usual tests) and for *assay* see U.S.P., p. 9 and also Part V of this book.

Remarks.—Citric acid was isolated by Scheele in 1789 from the juice of lemon, and analyzed by Liebig in 1831; while the structure of the body was proposed by Salet (1868) and confirmed by Grimaux and Adam (1880).

Citric acid occurs in the juice of the lemon and some other fruits, the former, however, being the source of the commercial article. By treating lemon-juice with calcium carbonate, calcium citrate is precipitated out, and this precipitate, after being thoroughly washed, is treated with sulphuric acid, whereby a precipitate of calcium sulphate is formed and citric acid goes into solution. The citric acid solution is then concentrated in vacuo and allowed to crystallize.

Several syntheses of citric acid have been accomplished, one of which is from carballylic acid, thus proving its structural formula. None, however, has attained commercial value.

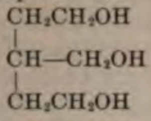
A fermentation process of manufacture in which glucose is acted upon by a special enzyme in the presence of a trace of nitrogenous matter, has been devised by Buchner.

Citric acid occurs in translucent, right-rhombic prisms, melting at 152° to 153°C., having the specific gravity 1.6, and soluble in 0.5 part of water.

Citric acid crystallizes with one molecule of water of crystallization, and is prone to efflorescence. Moreover, if the acid is heated to 175°C., it will not merely lose its water of crystallization, but also a molecule of water from its own structural formula, with formation of a new body, *aconitic acid.*

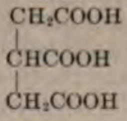
It may be well to compare the graphic formula of the three acids just mentioned along with the alcohol from which derived:

Primary triatomic hexyl alcohol.



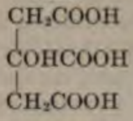
$$\begin{array}{l} CH_2CH_2OH \\ | \\ CH-CH_2OH \\ | \\ CH_2CH_2OH \end{array}$$

Tricarballylic acid.



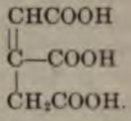
$$\begin{array}{l} CH_2COOH \\ | \\ CHCOOH \\ | \\ CH_2COOH \end{array}$$

Citric acid.



$$\begin{array}{l} CH_2COOH \\ | \\ COHCOOH \\ | \\ CH_2COOH \end{array}$$

Aconitic acid.



$$\begin{array}{l} CHCOOH \\ \| \\ C-COOH \\ | \\ CH_2COOH. \end{array}$$

The fact that citric acid easily parts with a molecule of water should always be borne in mind, and, therefore, undue heat should not be used in evaporating a solution of citric acid or of its salts. In fact, the evaporation should take place in vacuo.

Dose.—500 milligrammes (8 grains).

DRUGS CONTAINING FRUIT ACIDS

As this opens the subject of crude drugs, a few words of introduction may be advisable.

Vegetable drugs consist of whole plants, plant parts, or plant excretions, in other words, are portions of that collection of cells called a plant. Knowledge of plants forms the science of botany, and a full discussion of this science is clearly beyond the limits of this work; hence the student is referred to list of standard text-books given in the Preface. To explain the "official definitions" (p. 24) of the drugs that must be considered in this book a slight résumé of the important plant parts is in order and is here given, fuller details of peculiar cases being considered under drugs illustrative of each case.

The study of vegetable drugs—of the plant parts used in medicine—forms that branch of knowledge called organic materia medica, and even this in its complete form is beyond the province of this work, reference to the leading text-books on the subject being found in the Preface.

In the study of materia medica, drugs are usually grouped as belonging to the several classes of plant parts—roots, stems, rhizomes, tubers, woods, barks, leaves, bulbs, herbs, flowers, fruit, and seeds—hence it may be well to define these parts (or organs) at this place.

A *root* is that part of the plant axis that does not bear leaves. Roots are not always under ground; thus, ivy has roots above ground that aid the plant in climbing.

A *stem* is that portion of the plant axis which does bear leaves. All stems are not above ground; the so-called "roots" of the violet or of Solomon's seal, which run horizontally under ground, are stem parts, for the leaves spring directly from them.

A *rhizome* is that stem part which lives under ground. The violet stem part just mentioned is an example of a rhizome.

A *tuber* is a thickened underground stem, used as a reservoir for starch. Example, the Irish potato. In the case of some tubers, they more closely resemble roots than stems, and are then called *tuberous roots;* an official example of such as is found in aconite.

Stems of large plants like trees are called *trunks*, and such a *trunk* can be roughly divided into the central part, called the *wood*, and the outer, more or less corky layer, called the *bark.*

Leaves are expansions of the stem tissue arranged regularly on the stem. Ordinarily leaves perform the function of respiration or breathing, playing an important part in the conversion of carbon dioxide, which they absorb from the air, into starch, sugar, and cellulose.

Bulbs are collections of underground leaves attached to a stem which consists of nothing more than a conical disk from beneath which the rootlets project. The onion is a good example of a bulb. The difference between a tuber and a bulb may well be given here. An example of a tuber is the Irish potato, and as the example of a bulb the onion will be taken, and even slight examination will show that these two are different. Both grow underground, and neither is a root; yet they are not the same. A bulb, like a tuber, is an underground stem, but it goes farther, since it also includes distinct underground leaves. Thus, in the onion, the thick, juicy scales are the underground leaves, and all there is of the stem is the hard little base from which the rootlets grow and to which the scales (leaves) are attached.

Herbs represent the whole dried plant, usually deprived of its roots.

Flowers are leaf modifications which perform the function of reproduction, the special organs for this purpose being the ovary—the female organ—and the anther—the male organ. The fertilized ovary develops within itself—

Seeds, which are organisms containing a germ—the beginning of a new plant—provided with sufficient nourishment to support it during the first days of its sprouting.

Fruits represent the ripened ovary and its appendages. The appendages vary from a thin, chaff-like ovary wall, in anise, to the large luscious "meat" and thick green rind of the watermelon.

Chemically, drugs consist of many substances; those that are plant organs consisting, histologically, of cell-wall and cell-contents, drugs that are exudations from plants being usually entirely cell-contents. This cell-wall, which consists of cellulose, wood, bast, or cork, according to its development is generally spoken of pharmaceutically as "*fibrous tissue*." The cell-contents consist of a vast number of bodies, such as alkaloids, glucosides, neutral principles, oils (volatile or fixed), tannin, resin, gum, starch, sugar, etc. The last four are found in almost all plants, while the others are more sparingly found, and constitute the active principle of the specific drug under consideration.

This leads to the classification of drugs into alkaloidal drugs, glucosidal drugs, astringent drugs, etc. In the consideration of every drug on the pages which follow the *constituents* will be an important feature study, and let it be here frankly stated that under constituents will be given only those which make the drug of value. Thus in considering alkaloidal drugs a continuous repetition of "gum, starch, and sugar" will be omitted, reference being made to these constituents only when they play an important rôle.

Rhus Glabra (U.S.P. VIII; N.F. IV) are dried *sumac berries*. These enjoy some vogue as a remedy for sore throat; being made into an infusion, which is used as a gargle.

Tamarindus (U.S.P. VIII; N.F. IV), or *tamarind*, is a preserved pulp of the fruit of Tamarindus indica and is frequently found in commerce mixed with molasses.

Tamarinds are used as a refrigerant and laxative. A drink from tamarinds and cream of tartar is popular in the south for "thinning the blood."

Dose.—15 grammes (240 grains).

Limonis Succus (U.S.P. VIII), or *lemon juice*, is the commercial source of citric acid. Note that the original "neutral mixture" (Mistura Potassii Citratis, p. 418) was made by neutralizing lemon juice with potassium bicarbonate. It is a refrigerant and was formerly used on shipboard as a preventive of scurvy, a loathsome disease produced by a steady diet of salt meat. It is given in doses of 1 fluidounce.

Succus Citri, N.F., or *lime juice*, is expressed from the lime fruit, *Citrus medica acida*. From it is prepared *succus citri et pepsinum*, N.F., which is made by mixing 400 mils of glycerite of pepsin with 600 mils of lime juice.

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CHAPTER XXXIX

DERIVATIVES OF HEXANE

THE following derivatives of hexane (C_6H_{14}) are of interest:

Hexyl alcohols	$C_6H_{13}OH$.
Capronic acid	$C_5H_{11}COOH$.
Mannitol Dulcitol Sorbitol	$C_6H_8(OH)_6$.
Glucose, U.S.P.	$C_6H_{12}O_6$.
Sugar, U.S.P.	$C_{12}H_{22}O_{11}$.
Starch, U.S.P.	$(C_6H_{10}O_5)x$.
Gums	$C_6H_{10}O_5$.
Cellulose (purified cotton U.S.P.)	$(C_6H_{10}O_5)x$.
Pyroxylin, U.S.P.	Chiefly $C_{12}H_{16}(ONO_2)_4O_6$.
Glucosides.	
Tricarballylic acid	$C_3H_5(COOH)_3$.
Citric acid, U.S.P.	$C_3H_4(OH)(COOH)_3$.

Of the *hexyl alcohols*, seventeen are possible, but since none is of pharmaceutic value, they will not be noticed.

By the oxidation of one of these alcohols, *capronic acid*, $CH_3(CH_2)_4$-COOH, is obtained. This capronic acid is a fatty acid discovered by Chevreul in 1824, and is found as an ester in coconut oil, Limburger cheese, and goat butter, and is cited merely because it is the only monobasic acid of hexane of pharmaceutic interest.

Mannitol, $C_6H_8(OH)_6$, is the hexatomic alcohol of hexane. It was isolated by Proust from manna in 1806, and is also found in minute traces in other drugs. The chief source of commercial mannite is manna, from which it is obtained by treating with boiling alcohol. From the alcoholic solution the mannite separates on cooling in small white crystals of sweetish taste.

By careful oxidation it yields *mannose*, a variety of sugar, while oxidation with nitric acid yields *saccharic acid*.

Dulcite and *sorbite* are isomeres of mannite, the former obtained by reduction of lactose (milk-sugar) and the latter by reduction of glucose.

These three hexatomic alcohols yield ketone and aldehyde derivatives, which are of great importance, such as *glucose*, *mannose*, *cane-sugar*, *starch*, and *cellulose*.

The formula of the first two is $C_6H_{12}O_6$.

Cane-sugar is $C_{12}H_{22}O_{11}$.

Starch and cellulose $(C_6H_{10}O_5)_x$.

On examining these formulas it will be noticed that the hydrogen and oxygen atoms attached to the carbon atoms are present in exactly the same proportion as in water, viz., there are always twice as many hydrogen atoms as oxygen atoms. For this reason to this class of bodies was assigned the name "*carbohydrates*," although at present but little stress is laid on this characteristic.

Carbohydrates.—While most carbohydrates are derivatives of hexane, some are found containing more or less carbon than six. Thus, arabinose is $C_5H_{10}O_5$. On the other hand, some contain seven carbon atoms, some eight carbon atoms, and some nine; but practically all the carbohydrates are derivatives of hexane.

The hexane carbohydrates can be roughly grouped into three classes, the first having the form $C_6H_{12}O_6$, which have representatives in glucose and dextrose; the second, being of double formula, $C_{12}H_{22}O_{11}$, is found in cane-sugar; while the group $C_6H_{10}O_5$ has representatives in such well-known bodies as starch, gum, and cellulose.

The first examination of these bodies shows that one should be derived from the other, thus:

$2C_6H_{10}O_5$, which is	$C_{12}H_{20}O_{10}$
plus one molecule of water,	H_2O,
gives us a molecule of sugar	$C_{12}H_{22}O_{11}$,
and when to this we add another molecule of water,	H_2O,
we get	$C_{12}H_{24}O_{12}$
or	$2C_6H_{12}O_6$,
which is the formula of glucose.	

The transition of starch or sugar into glucose is really performed by the adding of water (by chemical means). The reverse operation is not so simple a one, and has not been performed.

On the other hand, one molecule of glucose minus one molecule of water gives the empiric formula of one molecule of starch or gum.

As in the case cited above, the transformation of glucose into starch has not been accomplished, but the reverse operation, the conversion of starch into glucose, is performed by the very simple act of heating the starch with dilute sulphuric acid. It may be as well to state right here that the agent used for the molecular addition of water is usually diluted sulphuric acid, and the process of chemically combining water is called "*hydrolyzing*." On the other hand, if it is desired to remove water from the molecule of an organic substance, concentrated sulphuric acid is usually the agent employed, when it is said to act as a "*dehydrator*."

The formula, $C_6H_{12}O_6$, it will be noticed, differs from the formula of mannitol, $C_6H_{14}O_6$, by containing two atoms of hydrogen less. It will be also noticed that this is the difference between the formula of an ordinary alcohol and its aldehyde or ketone, and it is really true that $C_6H_{12}O_6$ is an aldehyde or ketone derivative of the hexatomic alcohol, $C_6H_8(OH)_6$. The carbohydrates are called *aldoses*, or *ketoses*, according as the alcohol group has been changed to an aldehyde or a ketone, though some are of more intricate composition.

The carbohydrates can best be studied by taking up three groups in their regular order, viz.:

Those having formula $C_6H_{12}O_6$, or monosaccharides (monoses)
$C_{12}H_{22}O_{11}$, or bisaccharides (bioses).
$(C_6H_{10}O_5)_x$, or polysaccharides.

THE MONOSACCHARIDES

$(C_6H_{12}O_6)$

These are bodies of more or less sweetness, and all possess optical activity, that is, all deviate the ray of polarized light either to right or left, except the synthetic inactive varieties. According to Van t'Hoff's rule, each active substance should contain at least one asymmetric carbon atom, and investigation has shown that this is true in every case. Several syntheses of these bodies have been accomplished; thus paraformaldehyde cooked with milk of lime gives acrose; formaldehyde cooked with milk of lime gives a mixture of formose and acrose (p. 585). Likewise dibromide of acrolein (p. 611), when treated with barium hydroxide, gives acrose. The bodies of this series are all readily converted into alcohol when brought into contact with the ferment, yeast. If other bacteria of fermentation are added, they yield lactic or butyric acid or dextrin, as the case may be.

Following the rule of aldehydes and alcohols, these bodies of formula $C_6H_{12}O_6$ oxidize to special acids under special treatment, and, on the other hand, can be reduced to special alcohols.

They all combine with calcium or strontium to form alcoholates of the same. They give all the reactions characteristic of aldehydes and ketones, for example, form distinct crystalline bodies with phenyl hydrazine. Some bodies of the group (mannose and glucose) oxidize to the corresponding acid showing aldehyde characteristics, while the fructoses, under similar treatment, break up, showing their ketone characteristics.

The bodies of formula $C_6H_{12}O_6$ can be roughly divided into three groups:

Fructoses, $CH_2OH—(CHOH)_3—CO—CH_2OH$.
Mannoses, $CH_2OH—(CHOH)_4—CHO$.
Glucoses, $CH_2OH—(CHOH)_4—CHO$.

Of each of these, three varieties are known: (1) The levogyre, which rotate the ray of light to the left; (2) the dextrogyre, which rotate the ray to the right; and (3) the inactive, which do not affect the ray of light.

It will be noticed that levogyre is abbreviated to the letter "l," dextrogyre, to "d," and inactive, to "i," and let it be stated here that in future, in this work, these abbreviations will be used instead of the long technical names.

The three fructoses are as follows:

"l" fructose (*acrose*), which is of interest merely as one of the synthetic sugars.
"d" fructose (*fruit-sugar*), which is the sweet constituent of many fruits.
"i" fructose—*levulose.*

The three *mannoses* are of no pharmaceutic interest except as derivatives of mannite.

Of the three *glucoses*, the only one of interest is the dextrogyrate.

GLUCOSUM—Glucose

(**Glucos.**—Syrupy Glucose—Liquid Glucose)

A syrupy product obtained by the incomplete hydrolysis of starch, consisting chiefly of dextrose (d-glucose) $[C_6H_{12}O_6 = 180.10]$ and dextrins.

Summarized Description.

Colorless or slightly colored thick syrupy liquid; sweet taste; very soluble in water; sparingly soluble in alcohol. For details see U.S.P., p. 202.

For *tests for identity* and for *impurities:* Water (does not lose more than 21 per cent. on evaporation). Free acid (a modified volumetric test). Starch (not blue with iodine). Sulphur dioxide (does not reduce iodine). Heavy metals and arsenic (the usual tests) see U.S.P., p. 202 and also Part V of this book.

Remarks.—This product is the chief constituent of honey (which see), and can be made by inversion (hydrolysis) of cane-sugar and of starch, the reaction being as given on p. 623. The commercial source of glucose is corn, from which the embryo is removed by mechanical means, the residue treated with sodium hydroxide to remove gluten and albuminous matter naturally found in the corn, and the starch thus purified hydrolyzed by treating with sulphuric acid. On completion of the inversion, the excess of acid is neutralized by the addition of barium chloride, the precipitate of barium sulphate filtered out, and the aqueous solution of glucose concentrated in vacuo. Nowadays, hydrochloric acid is generally, used as the hydrolyzing agent. It is interesting to note that the separated embryo of the corn, when submitted to expression, yields a considerable quantity of fixed oil (*corn oil*), which is a valuable drying oil. The original intent of removing the germ was to prevent the glucose liquid from being greasy, and this affords another instance of the development of a special industry by the utilization of side-products. Glucose is placed on the market in two forms. One, is a thick, syrupy liquid, having specific gravity 1.412, perfectly miscible with alcohol and water.

A solid form of glucose is now obtainable, the terms *dextrose* and *grape-sugar* being at present reserved for this solid glucose. Glucose is a reducing agent, changing cupric salts to the cuprous form. Just as sulphuric oxide, SO_3, can be converted into sulphurous oxide, SO_2, by reduction, so can cupric oxide, CuO, (or its hydroxide, dissolved in excess of alkali), be reduced to cuprous oxide, Cu_2O, as shown below:

$$\begin{array}{lll} & 2CuO = Cu_2O_2 & \text{cupric oxide} \\ \text{less} & \qquad\quad \underline{O} & \\ & \text{yields} \quad Cu_2O & \text{cuprous oxide,} \end{array}$$

the valence of the copper being reduced during the reaction from II to I.

While this reaction occurs under the influence of any reducing agent, it is usually confined to the identification and estimation of glucose, for which it is admirably adapted, the brick-red precipitate of cuprous oxide being very characteristic. Glucose is a constituent of urine in diabetes, and in this way its identification is of much importance to the pharmacist. In examining the urine for sugar either Fehling's or Trommer's test is applied. The latter, which is the oldest, consists in treating the suspected urine with a solution of copper sulphate and a few drops of solution of soda (whereby the copper sulphate is converted into cupric hydroxide).

On boiling, this blue cupric hydroxide is converted into brick-red cuprous oxide if glucose or other reducing agent be present.

Fehling's solution is an improved modification intended for volumetric analysis. It contains sodium and potassium tartrate (Rochelle salt), in addition to copper sulphate and sodium hydroxide. It is found among the volumetric solutions of the pharmacopœia. (See Part V.)

Galactose ($CH_2OH(CHOH)_4CHO$).—This monose is made by inversion of milk-sugar. It oxidizes to mucic acid, and is of no pharmaceutic value.

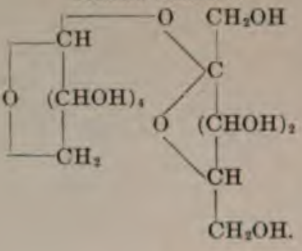
THE DI-SACCHARIDES

($C_{12}H_{22}O_{11}$)

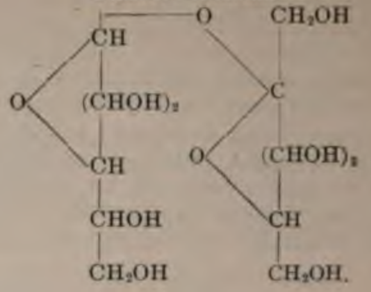
The bioses are those carbohydrates having the formula $C_{12}H_{22}O_{11}$, and, as mentioned above, these represent two molecules of $C_6H_{12}O_6$ minus one molecule of water. They are much more easily crystallized than the monoses, are optically active, and are fermentable only after being hydrolyzed, the sole exception to this statement being that maltose is directly fermentable. As already mentioned, the bioses, under treatment with dilute sulphuric acid and special ferments, such as diastase, are hydrolyzed into bodies having the formula $C_6H_{12}O_6$. Each biose yields different products under hydrolysis; thus cane-sugar hydrolyzes to glucose and fructose; maltose to glucose; lactose to galactose and glucose.

Maltose and lactose reduce silver nitrate and Fehling's solution, hence are aldehydes. Cane-sugar, on the other hand, does not act in this way, hence contains no aldehyde groups. All three of these bioses form esters of acetic acid containing eight acetyl groups, from which is deduced the fact that each contains eight hydroxyls. There is much in the chemistry of these bodies yet to be cleared, but from the few facts already mentioned it has been decided that they represent anhydrides of the various glucoses, evidently those into which they separate under hydrolysis. The exact chemical structure of these bodies has not been clearly ascertained, but the following formulas have been suggested for saccharose (cane-sugar):

Tollen's formula.



Fischer's formula.



SACCHARUM—Sugar

(Sacch.—Sucrose)

Sucrose $[C_{12}H_{22}O_{11} = 342.18]$ obtained from cultivated varieties of *Saccharum officinarum* Linné (Fam. *Gramineæ*), and from *Beta vulgaris* Linné, var. *Rapa* Dumort (Fam. *Chenopodiaceæ*) and from other sources.

Summarized Description.

White, hard, dry crystals or white crystalline powder; sweet taste; soluble in about 0.5 part of water, in about 137 parts of alcohol; insoluble in chloroform or ether; aqueous solution is dextrorotatory; $[\alpha]_D = +65.9°$. For details see U.S.P., p. 363.

For *tests for identity* and for *impurities:* Insoluble salts, ultramarine or Prussian blue (no sediment should deposit from its solution). Invert sugar (gravimetric copper test). Calcium, sulphate and chloride (usual tests) see U.S.P., p. 363 and also Part V of this book.

Remarks.—Sugar can be obtained from cane, *Saccharum officinarum*, beet, *Beta vulgaris*, or sorghum, *Andropogon Sorghum*, var. *Saccharatus*, the products in each case being chemically identical. The three varieties of commercial sugar are yielded by three distinct plants; those yielding sugar-cane and sorghum sugar greatly resemble the corn, and in both cases the stalks are cut near the roots at the proper season, the leaves lopped off from the stalks, which are then passed through rollers, by which means the juice is expressed. The juice is treated with lime to remove the gluten and albumin, and the lime removed as calcium carbonate, when the liquid consists of a thin solution from which sugar is obtained by appropriate concentration. At present, in place of lime, calcium bisulphite is frequently used. This chemical not merely removes the gluten and albumin, but also acts as an antiseptic. Formerly the light juice was concentrated in large pans under atmospheric pressure ("open kettle process"). In such cases, however, the solution underwent slight decomposition, darkening the product, and forming the commercial brown sugar. To refine this brown sugar it is necessary to redissolve and clarify it with albuminous matter, such as blood, filter through charcoal and the solution concentrated in vacuo, and at the present time this concentration in vacuo is done from the very beginning. When the liquid in the vacuum pan has reached a proper degree of concentration, and the sugar is beginning to separate out by crystallization, the mass is transferred to centrifugal machines and is entirely freed from moisture.

The process of making beet-sugar is more complicated than that of making cane-sugar, the saccharine solution being prepared by chopping the beets into small particles and macerating same in warm water, this process being known as the diffusion process. This solution contains many more impurities than does the cane-juice, hence many and complicated methods of purification have to be used, and in this way quite a number of side-products of more or less value are obtained. Thus, it will be recalled that methyl chloride (p. 580) is now obtained largely from beet-sugar residue.

The process of diffusion mentioned above is now used in some factories in the manufacture of cane-sugar. The cane, instead of being run through rollers, is relieved of its sugar by maceration in warm water. The extraction in this case is much more thorough than by pressure, but requires more manipulation, making the process more expensive.

Sugar appears in commerce usually in the granulated form, although in some sections of the world the old-fashioned sugar-loaf is still used. This is made by pouring the most concentrated warm solution of sugar into conical molds, letting stand twenty-four hours, draining off the syrup, and drying.

If a saccharine solution is allowed slowly to crystallize on strings, large transparent crystals are formed, these being known as *rock-candy*. Sugar melts at 160°C., and if the sugar which has been brought to the melting-point with the aid of a little water is then allowed suddenly to cool, it produces a candy form of sugar sometimes called *barley-sugar*. If sugar is heated to 200°C., the product begins to carbonize and results in a deep brown liquid called *caramel*. This liquid is used largely as a coloring matter in soda-water syrups; hence it will not be amiss to mention the details of preparation. Thus, if the carameled sugar is allowed to cool without addition of water, it will deposit in a difficultly soluble mass. The addition of cold water to the highly heated fused mass causes the sudden evolution of steam, with a sputtering which may be dangerous when manufacturing caramel; hence to insure perfect results, to the caramelized sugar at the proper stage should be added boiling water and not cold water.

In making sugar by the open kettle process there is obtained a large amount of brown mother liquor, and this contains a quantity of sugar in uncrystallized form, and the concentrated product is called *molasses*. In the modern manufacture of sugar the aim is to make as large an amount of sugar as possible, and therefore results in a corresponding loss in the yield of molasses. In the vacuum pan sugar-making the amount of molasses produced is very small, and even from this the sugar is extracted by treatment with strontium salts (which form soluble strontium saccharate), from which the sugar can be eventually isolated in crystalline form.

Sugar, U.S.P., is a white, crystalline solid, of specific gravity 1.340, and soluble in 0.5 part of cold water, and sparingly soluble in alcohol. When treated with concentrated sulphuric acid the water is extracted, leaving carbon behind, in other words, sulphuric acid carbonizes sugar. Its saturated aqueous solution forms *syrup*, U.S.P. Sugar is chiefly used as a sweetener, possessing in this way decided nutritive properties.

SACCHARUM LACTIS—Sugar of Milk

(Sacch. Lact.—Milk Sugar—Lactose)

Lactose [$C_{12}H_{22}O_{11} + H_2O = 360.19$] obtained from the whey of cow's milk. Preserve it in tightly closed containers.

Summarized Description.

Hard, white, crystalline masses, or white powder; faintly sweet taste; soluble in about 4.9 parts of water, almost insoluble in alcohol; insoluble in chloroform or ether;

aqueous solution is dextrorotatory; $[\alpha]_D = 52.2°$ to $52.5°$. For details see U.S.P. p. 363.

For *tests for identity* and for *impurities:* Dextrin (treated with 10 per cent. alcohol, the filtrate is not precipitated by dehydrated alcohol).

Cane sugar or glucose (the fluid just mentioned does not have more than 0.03 Gm. residue from 2 Gm. sugar of milk).

Starch (boiled solution not made blue with iodine).

Heavy metals (hydrogen sulphide test) see U.S.P., p. 364 and also Part V of this book.

Milk-sugar is that form of biose chemically called lactose, and is a normal constituent of milk. Up to very recent years practically all milk-sugar was made in Switzerland, as, in the United States, the whey after cheese manufacture was used to feed cattle. At present, however, much sugar of milk is made in this country, most of it being produced in New York State.

Milk-sugar is made in Switzerland by simple concentration of whey in open kettles and then crystallizing on sticks. In this country the whey is evaporated in vacuo, and the moist granular mass dried in a centrifugal machine.

Milk-sugar appears either in hard white crystals or in fine white powder, with a taste not so sweet as that of cane-sugar. As mentioned above, it directly reduces Fehling's solution, while cane-sugar has no action on Fehling's solution until hydrolyzed. Another point of chemical distinction between the two products is shown in the test of the pharmacopœia, namely, that milk-sugar when sprinkled upon concentrated sulphuric acid should not blacken the same; if it did, the presence of cane-sugar is indicated. In carrying out this test great care should be exerted to use nothing but the pure powdered milk-sugar. If fragments of the stick or string on which it crystallized were present, such would produce a brown color with the acid.

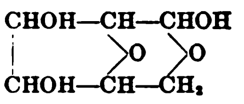
Maltose is the sugar which is found in official *malt*. Malt is made from barley by placing same in a warm, moist, light place, and when the seeds begin to sprout, they are heated sufficiently to destroy the life of the young plants. The sprouting of a seed means the gradual development of embryo found therein, and during the first stages of its development the starch which is stored up in the seed serves for its food until there is developed a sufficient number of leaves to generate its own food from the carbon dioxide of the air. The starch which is found in the seed has to be converted into soluble forms before it can be assimilated by the embryo, and in the case of barley, it is converted into maltose by the action of the ferment *diastase* naturally residing in the seed. In manufacturing malt from barley the latter is allowed to grow until practically all the starch has been converted into maltose by the diastase. Maltose is of interest only as the sugar constituent of *extract of malt* (which see).

THE POLYSACCHARIDES

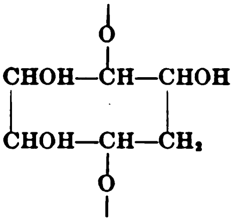
$(C_6H_{10}O_5)_x$

These furnish several well-known products, both cellulose and starch being examples. Both these bodies, however, are more complicated than the simple formula given above, and their composition is usually expressed by $(C_6H_{10}O_5)_x$. According to the investigation of Tollens, the x in the case of starch is 4, while it is assumed that the real formula of cellulose is $(C_6H_{10}O_5)_{12}$. Green and Perkin think that the graphic formula of cellulose is a multiple of figure "*a;*" while Mosenthal suggests the formula given in figure "*b.*"

(a)



(b)



Cellulose is so called because it represents the coating of the cell. Cells consist primarily of a semiliquid portion called the protoplasm and nucleus surrounded by a cell-wall, and this cell-wall, when in a state of the greatest purity, consists of pure cellulose. A striking illustration of pure cellulose in the form of cell-wall is found in the official *cotton*, which consists of the hairs of the seed of *Gossypium herbaceum*. In this case each hair consists of a single emptied cell, hence it is nothing but a cell-wall, and this, on chemical analysis, is shown to be pure cellulose.

Cotton consists of long filaments, insoluble in water, alcohol, and ether, but soluble in ammoniacal solution of copper oxide (not ammoniacal solution of copper sulphate, as mentioned in so many books). Cotton is used solely for mechanical purposes, and is of great value in pharmacy for such operations as filtering and straining, and in surgery as a dressing. The general use of cotton in the form of cloth is too well known to need remark.

GOSSYPIUM PURIFICATUM—Purified Cotton

(Gossyp. Purif.—Absorbent Cotton)

The hairs of the seed from one or more of the cultivated varieties of *Gossypium herbaceum* Linné (Fam. *Malvaceæ*), freed from adhering impurities and linters and deprived of fatty matter.

Summarized Description.

White, soft, fine filaments; insoluble in ordinary solvents; soluble in ammoniacal solution of copper oxide; ash, not more than 0.2 of 1 per cent. For details see U.S.P., p. 208.

For *tests for identity*, for *impurities;* acid or alkali (tested with phenolphthalein and with methyl orange).

Fatty matter (not more than 0.6 per cent. is soluble in ether).

Dyes (alcoholic percolate neither blue nor green).

Resins and soap (not more than 0.5 per cent. is soluble in alcohol), see U.S.P., p. 208, and also Part V of this book.

Remarks.—This represents raw cotton freed from fat by boiling in a very dilute alkaline solution, and washing very thoroughly with water the first portion of which has been acidulated. It is commonly called *absorbent cotton.*

Raw cotton floats when placed in water, because each filament is coated with a layer of oil, rendering the cellulose impervious to water, which cannot, therefore, displace the air in the lumen (the cavity) of the cell. In this way each filament of raw cotton is buoyed up by the air within its lumen. Absorbent cotton is this raw cotton freed from its oily covering. Water is, therefore, able to penetrate the cellulose and thus displace the air in the lumen. The cellulose itself being heavier than water, the water-filled filaments sink; hence a pledget of absorbent cotton placed upon water immediately falls to the bottom of the vessel.

Purified cotton is used as a surgical dressing and as a filtering medium.

Linen, the fibers of stem of the flax consists of a modification of cellulose and *silk,* the fibers of the cocoon of the silk-worm is a mixture of two protein substances; silk fibroin and silk gelatin.

Paper originally represented a special form of shredded linen or cotton. The details of the manufacture of paper are beyond the scope of this book, but suffice it to say that the mass of shreds, when rolled out into paper, forms an absorbent sheet known as filter- or blotting-paper, according to its thickness. Writing paper represents this absorbent paper, which has been coated with a layer of some substance which ink will not penetrate, such as a combination of glue with albumin, resin, or casein. Most paper now used in printing is, however, made from wood-fiber.

If cotton or linen paper is rapidly passed through 50 per cent. sulphuric acid, the outer layer of cells becomes converted into a starch modification (amyloid), forming the well-known product called *parchment paper.* If the paper is allowed to remain long in contact with sulphuric acid, it is converted into *dextrin,* which will dissolve in the acid. The same is true of absorbent cotton; it dissolves in concentrated sulphuric acid, but the solution in this case is different than is the solution of the cotton in ammoniacal copper oxide, because in the acid it dissolves not as cellulose, but as dextrin, whereas the copper solution is simply a solution of the cellulose from which the cotton can be redeemed by evaporation.

Cotton or cellulose, like glucose and the sugars, is an alcohol, as is proved by the fact that when treated with a mixture of nitric acid and sulphuric acid it is converted into the ester, nitrocellulose. Several forms of nitrocellulose are known, these being grouped into two classes—the first, true pyroxylins, and the colloxylins.

The first, which is the true *gun-cotton,* was discovered by Schoenbein in 1864, and has the formula $C_{12}H_{14}(ONO_2)_6O_4$, which, it will be noticed, contains six nitro-groups.

The second series, the colloxylins, are respectively:

$$C_{12}H_{15}(ONO_2)_5O_5,$$
$$C_{12}H_{16}(ONO_2)_4O_6,$$
$$C_{12}H_{17}(ONO_2)_3O_7,$$

containing five, four, and three nitro-groups. The true pyroxylin mentioned above is insoluble in a mixture of alcohol and ether, whereas the three colloxylins are soluble in a mixture of alcohol and ether. Which of these nitro-bodies is produced depends on the proportion of nitric and sulphuric acids employed and the duration of maceration.

Gossypium stypticum (N.F.), or *styptic cotton,* is absorbent cotton impregnated with *ferric chloride.*

PYROXYLINUM—Pyroxylin

(**Pyroxylin.**—Soluble Gun Cotton)

A product obtained by the action of a mixture of nitric and sulphuric acids on cotton and consisting chiefly of cellulose tetranitrate [$C_{12}H_{16}(ONO_2)_4O_6$ = 504.17]. Preserve it in cartons, packed loosely, and protected from light and moisture.

Summarized Description.

Yellowish-white matted masses of filaments looking like raw cotton; harsh to touch; very inflammable; explosive; decomposes when kept in closed bottles; soluble in mixture of 3 volumes of ether and 1 volume of alcohol, also in acetone and in glacial acetic acid. For details see U.S.P., p. 348.

For *tests for identity* and for *impurities.* Soluble matter (treated with water, the filtrate is not acid nor does it extract more than 0.3 of 1 per cent. of solid matter), see U.S.P., p. 349, and also Part V of this book.

Pyroxylin consists of a mixture of the three colloxylins (chiefly the tetranitrate) given above, and is made, as mentioned above, by immersing cotton in a mixture of nitric acid and sulphuric acid. An interesting fact in the manufacture worth pointing out is that the macerating cotton should be carefully covered, as it has been noticed that if a mixture is allowed to stand in a dish, particles of dust and the like are apt to start a new reaction in the mixture, with the ultimate formation of dextrin and complete solution of the pyroxylin.

The manufacture of pyroxylin is simple, but the freeing of the cotton from acid is tedious, and usually takes a large quantity of water for the purpose. If pyroxylin is not freed from acid, it will assume a brown tint and decompose. The same decomposition occurs if pyroxylin is kept in well-stoppered bottles, hence the pharmacopœia directs that it be kept in cartons.

The pyroxylin of the pharmacopœia has an appearance similar to that of cotton, but possesses a harsh feel, rather than the softness of the pure cotton. It should be completely soluble in a mixture of 1 part alcohol and 3 parts ether, and this solution, containing 4 per cent. of gun-cotton, is official under the name collodion (p. 213).

Gun-cotton is one of the most inflammable of substances, portions brought in contact with a flame instantly igniting with a very brilliant light, and leaving no trace of ash behind. Its great inflammability makes it a rather dangerous product to have around, and, therefore, it should be handled with the utmost caution and kept remote from heat or fire. If gun-cotton be heated in a confined space, the same decomposition occurs with explosive violence, and it is, therefore, used as an explosive.

Its action, however, is too uncertain to make it safe for this purpose; hence nitroglycerin is preferred for blasting rather than gun-cotton.

A mixture of pyroxylin with camphor, whitened with zinc oxide, and made pliable with castor oil, forms the well-known commodity *celluloid*. This possesses the same inflammability as pyroxylin, and, therefore, its use in various articles of apparel, such as combs, is not to be recommended. Non-inflammable formyl- and acetyl-cellulose products are now being made.

Artificial silks are prepared by treating cotton with certain chemicals producing cellulose products having the lustrous appearance of the product of the silk-worm. In one process, the cotton is dissolved in an ammoniacal solution of copper oxide and is then precipitated by addition of acids. The pulp mass thrown down is "spun" by pressing through minute orifices. In another process, nitrocellulose is prepared and the nitric acid is then removed by treatment with alkali; while" viscose" silk is sodium-cellulose thiocarbonate, made by treating paper in strong alkali and macerating the mercerized cellulose thus obtained, with benzin and carbon disulphide. The thiocarbonate which results is then treated with 10 per cent. alcoholic sulphuric acid and the resultant "viscose" is "spun" as described above. These substances can be "spun" in sheets and such "laminated silks" are now being sold under trade names as substitutes for sheet gutta-percha and oil silk as a protective coating for wounds.

Wood is cellulose which has become impregnated with lignin, $C_{40}H_{44}O_{11}$, and which is presumably a condensation product of coniferyl alcohol. The botanic side of wood has been considered on p. 619, and it needs, therefore, to be discussed at this place only as a chemical. Of late years the demand for cheap paper has led to the use of wood for the manufacture of paper instead of linen and cotton. Such paper is by no means as durable as that from pure cellulose, and it is often convenient to be able to decide whether a given sample of paper contains wood-fiber. This is very beautifully determined by pouring on the suspected paper a solution of aniline acetate.

If the paper is pure cellulose, no change of color will be produced, but with a slight amount of wood-fiber the reagent will form a brilliant yellow. If paper is treated with a solution of phloroglucin, followed by a few drops of concentrated hydrochloric acid, a bright red stain results if wood-fiber is present.

Starches represent bodies having the formula $(C_6H_{10}O_5)_x$. They are formed in the leaves of plants from carbon dioxide and water under the influence of chlorophyl, as already explained on p. 585 and represent the great plant reserve stuff.

During the time it is in leaf the plant manufactures starch, which is then stored up as nourishment for the young shoots of the following spring. While starch is formed in the leaves of plants, as these leaves are shed by the plant in the winter it is necessary that starch be stored in some other organ during that period; hence the starch formed in the leaves is transported to the organs in which it will be reserved (very frequently the roots or rhizome), where it is changed back into starch. Likewise in the spring, the stored matter is converted once more into sugar, which passes in solution up to the growing part of the plant. This solution is known as "sap," and commercial advantage is taken of the sugar contents of sap in the preparation of *maple-sugar*.

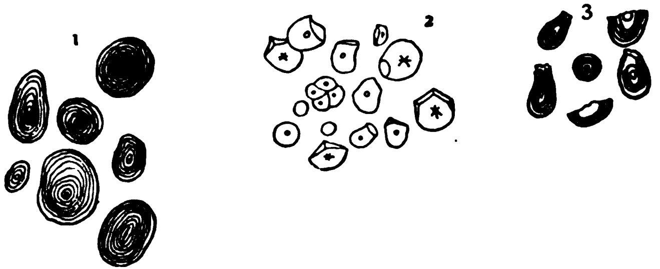


Fig. 242.—Microscopic appearance of different starches (uniform magnitude) (Noël): 1, Arrowroot; 2, raw tapioca; 3, tapioca.

Starch is found in various parts of the plant, in particles called starch-granules. The appearance of these granules is characteristic for the different varieties of starch, and some are shown in Fig. 242.

Hartwich and Wichmann have shown that a wheat starch granule weighs about 69 trillionths of a gramme; while a potato starch granule weighs about 7.6 billionths of a gramme.

The starches are usually insoluble in cold water, and on being treated with hot water swell into a paste, which is more or less soluble in water. The test for starch is that the addition of a drop of iodine to starch paste turns it blue, and if too much iodine is added, it becomes black.

As mentioned above, starch is converted by the ferment diastase into maltose (p. 628), while the same starch treated with sulphuric acid is converted into glucose.

The most abundant starch is that from potato, from which it is extracted by a very simple process, grated potato being poured into troughs over which water is allowed to run, the water dissolving out the abuminates and other soluble principles, while the starch settles in the bottom of the trough in which it is collected. This potato starch is the well-known starch used in laundries, the starch for food or medicine being obtained either from corn or wheat.

AMYLUM—Starch

(Amyl.—Corn Starch)

The starch grains separated from the grain of *Zea Mays* Linné (Fam. *Gramineæ*).

Summarized Description.

Fine powder or irregular, annular, white masses, consisting of polygonal, spheroidal starch grains, insoluble in cold water and in alcohol; boiled with 15 parts of water it yields a jelly. For details see U.S.P., p. 49.

Remarks.—The official starch is that from corn. As seen in the picture, starch-granules from the same source are similarly marked, having more or less well-defined concentric rings radiating from a central spot called the hilum.

Starch Modifications.—*Lichenin* is a variety of starch found in Irish moss. It does not turn iodine blue.

Inulin is a starch modification found in roots of the natural order Compositæ. It differs from starch in being soluble in water, from which it separates in crystalline form and turns iodine yellow instead of blue.

Glycogen is a starch modification which is of interest only because of its animal origin, being found in the liver.

GUMMY SUBSTANCES

Gums have a composition similar to starch. They differ from starch in being either soluble in cold water or swelling to a jelly therein, and in being precipitated from aqueous solution by alcohol. On oxidation with nitric acid they yield mucic acid, while starch on oxidation with nitric acid yields dextrin.

Among the gummy principles of pharmaceutic importance are the following:

Dextrin, made by oxidation of starch with nitric acid, this being the commercial method of manufacture.

It is also produced by simply heating starch, and it is of passing interest to note that the polish we see on the outer surface of a loaf of bread is due to the dextrinization of the starch of the flour, and to the same cause is due the high polish acquired by ironing well-starched linen.

Dextrin is a whitish-yellow body, dissolving in water to form mucilage, for which purpose it is chiefly employed. On account of the high price of gum arabic, dextrin has been suggested as an emulsifier in making cod-liver oil, and, in fact, a recipe for making an emulsion with dextrin was given in the third edition of the National Formulary. Such emulsions have never yielded satisfactory results in the writer's experience.

Arabic Acid.—This is the active principle of acacia, where it is found as the calcium salt (*arabin*). On hydrolysis it yields glucose and arabinose, the latter a carbohydrate having the formula $C_5H_{10}O_5$.

Bassorin is the chief constituent of gum tragacanth. It differs from dextrin in the fact that it does not dissolve in cold water, but simply swells to form mucilage.

Cerasin, or fruit-gum, is the well-known exudation from peach and plum trees. It is insoluble in water, but dissolves in alkali.

Pectins are acid combinations of carbohydrates. They are found in various vegetable juices, and under the influence of a ferment, *pectase* they coagulate. This explains the manufacture of jellies from fruit-juices, and also explains why preparations of some drugs, notably senega, gelatinize. Bertrand and Mallévre found that calcium, or one of the other alkaline earths, is necessary to produce gelatinization, proving that the coagulated mass is the calcium salt of pectic acid, and not pectic acid itself.

SACCHARINE DRUGS

MANNA—Manna

The dried saccharine exudation of *Fraxinus Ornus* Linné (Fam. *Oleaceæ*).

Constituents.—Mannitol, sugar, dextrin. *Fraxin*, $C_{16}H_{18}O_{10}$.

Remarks.—Manna exudes from the trunk of the manna ash during the heat of the day, solidifying in the chill evening air. The pharmacopœia directs the use of what is commercially called "large-flake" or "small-flake," manna, "sorts" manna being rejected. A favorite method of administration is as "senna, manna, and salts" (compound infusion of senna, p. 217).

Medical Properties.—Laxative.

Dose.—15 grammes. (240 grains).

MALTUM—Malt

The grain of one or more varieties of *Hordeum sativum* Jessen (Fam. *Gramineæ*), partially germinated artificially, and then dried at a temperature not exceeding 55°C. It is capable of converting not less than 5 times its weight of starch into sugars. Protect it from heat and moisture.

Summarized Description.

Yellowish or amber-colored grains; agreeable characteristic odor; sweet taste; not less than 70 per cent. of soluble solids; not more than 0.3 per cent. acidity (calculated as lactic acid.) For details see U.S.P., p. 265.

For *assay* see U.S.P., p. 266.

Constituents.—Maltose and diastase.

Remarks.—Malt is barley-seed permitted to begin to sprout when the insoluble starch is converted by the ferment diastase into soluble sugar (maltose), that it can be of service in feeding the young plant. So soon as this conversion is accomplished the plant life is destroyed by heating to 70°C. Malt is official merely because used for making the official extract of malt (p. 278).

MEL—Honey

A saccharine secretion deposited in the honeycomb by the bee, *Apis mellifera* Linné (Fam. *Apidæ*).

Summarized Description.

Thick, syrupy, light yellow or yellow-brown liquid; characteristic odor; sweet, faintly acrid taste; levorotatory; diluted with twice its weight of water, the liquid has sp. gr. 1.099. For details see U.S.P., p. 269.

For *tests for identity* and for *impurities:* Starch or dextrin (boiled with water, solution not colored blue, green or red with iodine). Foreign colors or azo dyes (color of solution not changed on adding ammonia or hydrochloric acid). Invert sugar (ethereal extract not colored orange, cherry or brown red with resorcinol). Chlorides and sulphates (usual test), see U.S.P., p. 269, and also Part V of this book.

Constituents.—Dextrose, levulose, traces of cane-sugar, and dextrin, particles of wax.

Remarks.—Honey usually represents the nectar extracted from flowers by the bee and stored in the honeycomb for food purposes.

That the bee is able to produce a chemical change in the nectar in transferring it from the flower to the comb is shown by the ability of captive bees to convert dextrogyrate sugar to levogyrate honey. The tests for honey given above are important, as commercial honey is notoriously adulterated with artificial glucose (starch sugar). The barium chloride test for sulphates has a bearing on this point, since most commercial glucose contains traces of sulphates from the sulphuric acid used in producing it from starch.

For clarified honey, U.S.P., see p. 204.

Medical Properties.—Practically none, save as a pharmaceutic vehicle and as an excipient.

Dose.—4 mils (1 fluidrachm).

Prunum (U.S.P. VIII; N.F. IV), or *prune,* the partly dried ripe fruit of *Prunus domestica* Linné (Fam. *Rosaceæ*); contains sugar, malic acid, pectin, and is used as a laxative and nutritive. It is an ingredient of confection of senna, N.F.

Cassia Fistula (U.S.P. VIII; N.F. IV), or *cassia fistula,* the dried fruit of *Cathartocarpus* Linné Persoon (Fam. *Leguminoseæ*), contains sugar, gum, pectin, and citric acid and is an ingredient of confection of senna, N.F. It is a laxative in 60-grain doses.

Ficus (U.S.P. VIII; N.F. IV), or *fig,* is the partially dried fruit of *Ficus Carica* Linné (Fam. *Moraceæ*). It contains sugar, gum and nitrogenous bodies. Its only true fruit part is the tiny seed "seeds" (or achenes). The so-called fruit is the basis (receptacle), upon the hollow interior surface of which rest the separate minute flowers and the fruit produced therefrom. Such fruit is called a syconium. Figs are demulcent, laxative, and nutritive. It is a constituent of confection of senna.

TRITICUM—Triticum

(**Tritic.**—Couch Grass—Dog Grass)

The dried rhizome and roots of *Agropyron repens* (Linné) Beauvois (Fam. *Gramineæ*), gathered in the spring.

Constituents.—Levulose, triticin, malates, mucilage.

Remarks.—This drug is known as *couch grass* and *quick grass.* It has already been discussed as yielding a fluidextract made with aqueous menstruum (p. 246).

Medical Properties.—Diuretic.

Dose.—8 grammes (120 grains).

MUCILAGINOUS DRUGS

A mucilaginous drug is one containing one of the gums, discussed from the chemical standpoint on p. 633. To what is there stated need only be added the warning that many substances commonly called "gums" are not true gums, in the modern pharmaceutic sense Thus "gum elastic" (or rubber) and "chicle gum" (the basis of modern chewing-gum) are dried milk-juices; "gum asafetida" (p. 777) and "gum myrrh" (p. 777) are gum resins; "gum camphor" (p. 733) is the solid part of a volatile oil; "gum turpentine" (p. 765) is an oleoresin; "gum tolu" (p. 679) is a balsam; "gum mastic" (p. 774) and "gum benzoin" (p. 776) are resins, and so on.

What these substances—milk-juices, gum resins, oleoresins, balsams, etc.—really are will be explained in the appropriate place, and here let it be said that a true gum is a carbohydrate derivative, more or less soluble in water (forming an adhesive solution or paste) and insoluble in alcohol.

ALTHÆA—Althæa

(Marshmallow Root)

The root of *Althæa officinalis* Linné (Fam. *Malvaceæ*) deprived of the brown, corky layer and small roots, and carefully dried. Preserve Althæa in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride from time to time, to prevent attack by insects.

Constituents.—Mucilage, asparagin (p. 614), starch, sugar, pectin.

Remarks.—This drug is commonly called "marshmallow root," and it might be said, in passing, that the confection, "marshmallow drops," originally contained this drug. Now it is innocent of such admixture, being made from sugar and gum dusted with cornstarch. Powdered althæa is a valuable absorbent medium for making pills from liquids.

Medical Properties.—Demulcent, usually in the form of syrup (syrupus althææ, N.F., p. 202).

ULMUS—Elm

(Elm Bark—Slippery Elm)

The bark of *Ulmus fulva* Michaux (Fam. *Ulmaceæ*), deprived of the outer corky layer and dried.

Constituents.—Mucilage, trace of tannin, and only a very little starch.

Remarks.—Ulmus or *slippery-elm bark* is the inner bark of the special kind of elm tree, the periderm or corky bark having been removed.

Medical Properties.—Demulcent and emollient. The mucilage (mucilago ulmi, U.S.P. VIII, p. 193) is used as a basis of domestic cough remedies, while the ground bark is used as a soothing poultice.

Sassafras medulla (U.S.P. VIII; N.F. IV) or *sassafras pith* is obtained from *Sassafras variifolium.* It contains a mucilage which is not precipitated from aqueous solution by alcohol. It is used as a demulcent and its cold infusion, *mucilago sassafras medullæ* N.F. (p. 193), is used as a soothing basis for eye lotions.

AGAR—Agar

(Agar-agar)

The dried mucilaginous substance extracted from *Gracilaria* (*Sphærococcus*) *lichenoides* Greville and other marine algæ growing along the eastern coast of Asia, particularly several species of *Gelidium*, or *Gloiopeltis* (Class *Rhodophyceæ*).

Constituents.—Chiefly gelose, a carbohydrate that hydrolyzes to galactose; ash (about 4 per cent.) consisting largely of diatoms or fossilized microscopic plants.

Remarks.—Agar comes from the Orient and is prepared from sea weeds. It occurs in thin, translucent membranes and boiled with 100 parts of water, yields upon cooling a stiff jelly.

Medical Properties.—Now very popular as a mechanical remedy for constipation, by forming with the fluids of stomach and intestines a jelly which increases in bulk and causes a movement of the bowels. It is also used for making culture media in bacteriological work.

Dose.—10 grammes (2 drachms).

ACACIA—Acacia

(Acac.—Gum Arabic)

The dried gummy exudation of *Acacia Senegal* Willdenow, and of other African species of *Acacia* (Fam. *Leguminosæ*).

Constituents.—Arabin, a levogyre gum, chiefly calcium salt of arabic acid, which hydrolyzes to arabinose, $C_5H_{10}O_5$. It also contains an oxydase that causes the color changes when it is mixed with guaiac.

Remarks.—Acacia is precipitated from solution by lead subacetate, ferric chloride, and saturated solution of borax; hence these substances should not be prescribed with mucilage of acacia; alcohol also precipitates the mucilage. A mucilage made from 3 parts of acacia and 6 parts of water will, however, stand the addition of 1 part of alcohol.

Medical Properties.—Demulcent. It is the most important pharmaceutic adhesive agent, and is employed for this purpose in emulsions. Official preparations: Syrup of acacia (p. 196) and mucilage of acacia (p. 193).

TRAGACANTHA—Tragacanth

(Trag.—Gum Tragacanth)

The spontaneously dried gummy exudation from the stems of *Astragalus gummifer* Labillardiere, or from the other Asiatic species of *Astragalus* (Fam. *Leguminosæ*).

Constituents.—Water-soluble gum, similar to arabin; bassorin, $C_{12}H_{20}O_{12}$ which does not dissolve in water, but simply swells therein, making a jelly; cellulose.

Remarks.—Tragacanth differs from acacia in swelling to a jelly, when mixed with water, instead of dissolving therein, as does acacia. The official mucilage (mucilago tragacanthæ, p. 193) is largely used as a basis for jellies for chapped hands. It is also an excellent pill excipient. Powdered tragacanth is frequently adulterated with *Indian gum*, an exudation from Sterculia urens and with *sarcolla*, which is obtained from other species of Astragalus.

Medical Properties.—Demulcent.

CHONDRUS—Chondrus

(Irish Moss—Carrageen)

The dried plant of *Chondrus crispus* (Linné) Stackhouse and *Gigartina mamillosa* (Goodenough et Woodward) J. Agardh (Fam. *Gigartinaceæ*).

Constituents.—Pectin (called *carragheenin* by Pareira), mucus, and traces of iodine and bromine.

Medical Properties.—Chondrus (*Irish moss or carragheen*) is used as a demulcent and nutritive, being always administered in the form of a jelly made by boiling one part of drug with thirty parts of water and letting strained solution cool. The decoction, carefully evaporated, and the syrupy residue poured on glass plates, yields scaled *Irish moss gelatin*, (or *gelatinum chondri* N.F.) recommended by Emlen Painter as an emulsifying base.

Cetraria, the lichen, *Cetraria islandica*, was official in former pharmacopœias, but was dropped in the revision of 1890. It contains two mucilaginous principles, *lichinin*, $C_{12}H_{20}O_{10}$, and *lichnoid*, and a bitter principle, *cetraric acid*, since discovered to be a mixture. It was used as a nutritive in sick diet in the form of jelly (decoctum cetrariæ, U.S.P. 1890). For this purpose, however, the bitter cetraric acid had to be removed before jelly was made; hence the directions in making the decoction to throw away the first water in which the drug was washed (p. 218).

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CHAPTER XL

GLUCOSIDES AND GLUCOSIDAL DRUGS

THE large and important class of plant principles called glucosides are ethers of glucose with complex bodies, the usual definition of glucosides being *bodies which, when treated with a diluted acid or a ferment, split into glucose and some other body.*

This "other body" is usually of complex character, the composition of which is little known. In most cases the glucoside derivatives are compounds of benzene, and as the knowledge of these derivatives is extended and they are placed in their proper position in systematic chemistry, the glucoside in question can be more properly studied under such heading. Already we are confronted with this condition in the glucosidal drugs bitter almond and black mustard. In each case the product of hydrolysis is of more pharmaceutic importance than is the glucoside itself, hence black mustard is studied among the thiocyanates (p. 674), while the bitter almond is considered along with the benzaldehydes (p. 705).

Even the word "glucose," used in the above definition, does not indicate the definite chemical we know by that name. As already learned, there are a large number of bodies having the formula $C_6H_{12}O_6$, and "glucose" in the above definition means any one of these. More than that, some glucosides yield carbohydrates other than hexoses; thus, digitalin is said to yield digitalose, $C_7H_{14}O_5$.

Rosenthaler has attempted a classification of glucosides which we condense in the following table. In this, the word "aglycone" refers to the "other substances" produced by the hydrolysis of the glucosides

- A. *Glucosides with nitrogen free aglycones.*
  - I. Yielding *aliphatic aglycones.*
    - (*a*) *Alcohols.*
    - (*b*) *Aldehydes.* } Of little importance.
    - (*c*) *Ketones.*
    - (*d*) *Acids.* Examples, jalapin, convolvulin and glycyrrhizinic acid.
  - II. α. Yielding *aromatic aglycones.*
    - Benzene derivatives.
      - (*a*) *Alcohols.* Of little importance.
      - (*b*) *Phenols.* Examples, arbutin and methyl-arbutin.
      - (*c*) *Phenolic alcohols.* Examples, salicin and populin.
      - (*d*) *Phenolic acids.* Examples, gallic acid and tannic acid glucosides.
    - β. Yielding *styrol derivatives.*
      - (*a*) *Alcohols.* Examples, coniferin and syringin.
      - (*b*) *Phenolic acids and lactones.* Examples, caffetannic acid, daphnin, æsculin and fraxin.
      - (*c*) Phenolic esters. Example, hesperidin.
    - δ. *Anthracene derivatives.* Examples, frangulin and barbaloin.
  - III. Yielding *heterocyclic aglycones.*
    - α. *Flavone derivatives.* Examples, quercetin.
- B. *Glucosides with aglycones containing nitrogen.*
  - I. *Yielding aliphatic aglycones.* Of little importance.
  - II. *Yielding aromatic aglycones.* Example, amygdalin and similar glucosides.
- C. *Glucosides with aglycones containing nitrogen and sulphur.*
  - I. *Yielding aliphatic aglycones.* Example, sinigrin.
  - II. *Yielding aromatic aglycones.* Example, sinalbin.

The word "*hydrolysis*" used above expresses the process of decomposing chemical substances by introducing the element of water, this being the function of the diluted acid or the ferment in the decomposition of glucosides, as expressed in the following equations, illustrative of a few examples of such decomposition of glucosides:

Amygdalin plus Water equal Glucose plus Hydrocyanic acid plus Benzaldehyde.
$C_{20}H_{27}NO_{11} + 2H_2O = 2C_6H_{12}O_6 + HCN + C_6H_5CHO$

Arbutin plus Water equal Glucose plus Hydroquinone plus Methyl hydroquinone.
$C_{25}H_{34}O_{14} + 2H_2O = 2C_6H_{12}O_6 + C_6H_4(OH)_2 + CH_3C_6H_3(OH)_2$

Digitalin equals Digitaligenin plus Glucose plus Digitalose.
$C_{35}H_{56}O_{14} = C_{22}H_{30}O_3 + C_6H_{12}O_6 + C_7H_{14}O_5$

Digitonin plus Water equal Digitogenin plus Galactose plus Dextrose.
$C_{27}H_{44}O_{13} + 2H_2O = C_{15}H_{24}O_3 + C_6H_{12}O_6 + C_6H_{12}O_6$

Digitoxin plus Water equal Digitoxigenin plus Digitoxose.
$C_{34}H_{54}O_{11} + H_2O = C_{22}H_{32}O_4 + 2C_6H_{12}O_4$

Gentiopicrin plus Water equal Gentiogenin plus Glucose.
$C_{16}H_{20}O_9 + H_2O = C_{10}H_{10}O_4 + C_6H_{12}O_6$
Glycyrrhizin plus Water equal Glycyrrhetinic Acid plus Glycuronic Acid
$C_{44}H_{64}O_{19} + 2H_2O = C_{32}H_{48}O_7 + 2C_6H_{10}O_7$

Ipuranol plus Water equal Dextrose plus Phytosterol.
$C_{33}H_{56}O_6 + H_2O = C_6H_{12}O_6 + C_{27}H_{46}O$

Myronic Acid plus Water give Glucose plus Potassium Bisulphate plus Oil Mustard.
$C_{10}H_{16}KO_9NS_2 + H_2O = C_6H_{12}O_6 + KHSO_4 + C_3H_5CSN$

Salicin plus Water equal Glucose plus Saligenin.
$C_{13}H_{18}O_7 + H_2O = C_6H_{12}O_6 + C_7H_8O_2$

Strophanthin gives Strophanthidin plus Strophantho-biose-methyl-ether plus Water.
$C_{40}H_{66}O_{19} = C_{27}H_{38}O_7 + C_{12}H_{21}O_{10}CH_3 + 2H_2O$

The following glucosides have been studied, but not sufficiently to furnish complete equation:

Chiratin hydrolyzes to ophelic acid and chiratogenin.
Colocynthin hydrolyzes to colocynthein and sugar.
Convallarin hydrolyzes to convallaretin.
Convallamarin hydrolyzes to convallamaretin.
Ericolin hydrolyzes to ericinol.
Parillin hydrolyzes to parigenin.
Scammonin hydrolyzes to scammonol, valerianic acid, and grape sugar.
Saponin hydrolyzes to glucose and sapogenin.

SAPONINS

Under the head saponin we include a large number of glucosides frothing like soap when shaken with water, usually toxic, and while closely similar, are not identical in chemical composition, nor is the hydrolysis product, sapogenin, identical in each case. The following list gives the composition of typical saponins as reported by Kobert:

General Formula $C_nH_{2n-8}O_{10}$
(36 known)

Senegin	$C_{18}H_{28}O_{10}$, from senega.
Quillajic acid	$(C_{19}H_{30}O_{10})_3$, from quillaja.
Smila-saponin	$(C_{20}H_{32}O_{10})_5 + 12H_2O$ from sarsaparilla.
Sarsa-saponin	$(C_{22}H_{36}O_{10})_{12} + 24H_2O$ from sarsaparilla.
Parillin	$C_{26}H_{44}O_{10}$, from sarsaparilla.

General Formula, $CnH_{2n-16}O_{28}$
(8 known)

Schmiedeberg's digitonin	$C_{51}H_{86}O_{28}$, from digitalis.
Windhaus' digitonin	$C_{55}H_{94}O_{28}$, from digitalis.

Secondary Glucosides from Saponins, $CnH_{2n-6}O_7$
(10 known)

Senegenin	$C_{20}H_{32}O_7$, from senega.
Melanthinic acid	$C_{20}H_{32}O_7$, from veratrum.

Sapogenins, $CnH_{2n-6}O_2$
(6 known)

Parillin sapogenin	$C_{14}H_{22}O_2$
Quillaja sapogenin	$C_{14}H_{22}O_2$

Sapogenins, $CnH_{2n-6}O_3$

Sarsa-saponin sapogenin	$(C_{14}H_{22}O_3)_2$.
Kiliani's digitogenin	$(C_{15}H_{24}O_3)_2$.

Van der Haar has shown that the sapogenins, on distillation with zinc dust yield terpene derivatives.

GLUCOSIDAL DRUGS

As mentioned above, glucosides owe their characteristics primarily to those products of hydrolysis other than glucose, and as these products possess widely varying properties, the grouping of glucosidal drugs brings together agents showing marked difference in medical action. In an attempt to bring a semblance of order into this therapeutic confusion the drugs considered in this chapter will be grouped as follows:

Drug containing sweet glucosides	Glycyrrhiza.
Drugs containing bitter glucosides	Gentian.
Drugs containing glucosides acting on heart	Strophanthus, squill, and digitalis.
Drugs containing purgative glucosides	Lappa, jalap, scammony root, colocynth pulp.
Drugs containing astringent glucosides	Uva ursi.
Drugs containing saponin	Sarsaparilla and senega.

GLYCYRRHIZA—Glycyrrhiza

(Glycyrrh.—Licorice—Liquorice Root)

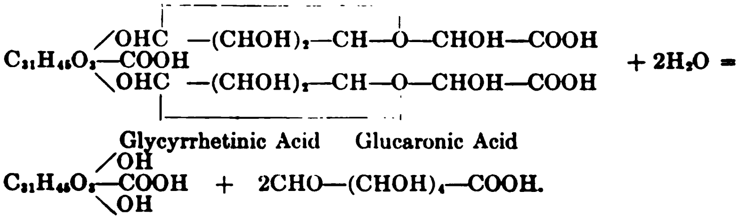
The dried rhizome and roots of *Glycyrrhiza glabra typica* Regel et Herder, known in commerce as Spanish Licorice, or of *Glycyrrhiza glabra glandulifera* Regel et Herder, known in commerce as Russian Licorice (Fam. *Leguminosæ*).

Preserve powdered and whole Glycyrrhiza in tightly closed containers to which a few drops of chloroform or carbon tetrachloride are added from time to time to prevent attack by insects.

Constituents.—Glycyrrhizin or glycyrrhizic acid, the potassium and calcium salts being the combination found in the drug; glucose, mannitol, asparagin, fat and resin, glycyrrhamarin; and a trace of volatile oil.

Tschirch's researches show that glycyrrhizin is not a true glucoside since its hydrolysis product is not an ordinary carbohydrate. The following gives both the hydrolysis equation and the graphic formulæ of the ingredients and reaction products.

Glycyrrhizin Acid.
(Glycyrrhizin)



$$C_{31}H_{46}O_3\begin{cases}OHC—(CHOH)_2—CH—O—CHOH—COOH\\—COOH\\OHC—(CHOH)_2—CH—O—CHOH—COOH\end{cases} + 2H_2O =$$

$$C_{31}H_{46}O_3\begin{cases}OH\\—COOH\\OH\end{cases} + 2CHO—(CHOH)_4—COOH.$$

Remarks.—The pharmacopœia permits the use of both Spanish and Russian licorice, the latter being larger than the Spanish, and comes into commerce peeled. It is sweeter than the Spanish, hence preferable.

Medical Properties.—Demulcent and expectorant. Used largely to disguise the taste of quinine and other bitter substances, for which purpose *ammoniated glycyrrhizin* or the *fluidextract* (p. 247) is used.

The other official preparations of glycyrrhiza are the pure extracts (p. 277), brown mixture (p. 257), and compound licorice powder (p. 293).

Dose.—2 grammes (30 grains).

GLYCYRRHIZINUM AMMONIATUM—Ammoniated Glycyrrhizin

(Glycyrrh. Ammon.)

Summarized Description.

Dark brown or reddish-brown scales; very sweet taste; soluble in water and in alcohol; ash not more than 0.5 per cent. For details see U.S.P., p. 207.

Remarks.—This substance, representing the glycyrrhizin in more or less impure form, is made by precipitation from an ammoniacal aqueous percolate of glycyrrhiza by means of sulphuric acid. The crude precipitated glycyrrhiza is dissolved in ammonia water and water, is reprecipitated with acid, again dissolved in ammonia water and water, and then "scaled" (p. 517).

Medical Properties.—This product is used entirely for masking taste of bitter substances.

Dose.—250 milligrammes (4 grains).

GENTIANA—Gentian

(Gentian—Yellow Gentian Root)

The dried rhizome and roots of *Gentiana lutea* Linné (Fam. *Gentianaceæ*).

Constituents.—*Gentiopicrin*, a bitter glucoside; *gentianin*, a bitter principle; *gentisin*, when fused with potassa, yields *gentisic acid* (dihydroxy-benzene-carboxylic acid) a body that turns deep blue with ferric chloride, etc.

Gentian contains no tannin, the darkening of its preparations by iron salts being due to gentisin and gentisic acid.

Remarks.—Gentian preparations yield unsightly mixtures when combined with iron unless the gentisin is removed by treatment of the preparation with ferric hydroxide or unless tincture of citro-chloride of iron, N.F., is employed.

The National Formulary gives recipes for four elixirs of gentian. (See p. 208.) Of these, the most popular is the *glycerinated elixir of gentian* which is similar to the so-called "glycerin tonic," which is largely prescribed.

Medical Properties.—Simple bitter, stimulates digestion and improves the appetite.

Administered as *fluidextract* (p. 244) and as *compound tincture of gentian* (p. 227). The official *extract* (p. 276) is a useful excipient for tonic pills, but should not be used for this purpose by a pharmacist unless so prescribed by the physician.

Dose.—1 gramme (15 grains).

Chirata (U.S.P. VIII; N.F. IV) is the dried plant of *Swertia Chirayita* (Roxburgh) Hamilton (Fam. *Gentianaceæ*). It contains *ophelic acid* and *chiratin*, the latter a glucoside. It is an East Indian herb of intensely bitter taste, little used in this country, but quite popular in England, and is used as a simple bitter in 15-grain doses.

SALICINUM—Salicin

(Salicin.)

A glucoside [$C_{13}H_{18}O_7$ = 286.14] obtained from several species of *Salix* and *Populus*. (Fam. *Salicaceæ*). Preserve it in well-closed containers.

Summarized Description.

Colorless silky shining crystalline needles, or rhombic prisms or white crystalline powder; soluble in about 23 parts of water and in about 71 parts of alcohol; insoluble in ether or chloroform; melts between 198° and 202°C.; levorotatory. For details see U.S.P., p. 364.

For *tests for identity*, for *impurities:* Salicylic acid (not colored violet with ferric chloride). Alkaloids (not precipitated by alkaloidal reagents). Heavy metals (hydrogen sulphide test), and for *assay* see U.S.P., p. 364 and also Part V of this book.

Extraction.—Salicin is prepared by making an aqueous infusion of willow bark, precipitating the gum and starchy matter from the infusion by treatment of lead subacetate, removing the excess of lead acetate by treatment with calcium carbonate. The filtrate is then concentrated in order to permit the crystals of salicin to separate out. These are purified by recrystallization.

Remarks.—As mentioned at the beginning of this chapter, salicin hydrolyzes to saligenin. The latter oxidizes to salicylic aldehyde and salicylic acid (p. 709).

Medical Properties.—Febrifuge and antirheumatic.

Dose.—1 gramme (15 grains).

Scutellaria (U.S.P. VIII; N.F. IV) or *skull cap* is the dried plant of *Scutellaria lateriflora* Linné (Fam. *Labiatæ*). It contains a glucoside, *scutellarin* and a trace of volatile oil. It is a tonic and is popularly supposed of value as a nervine. Its dose is 15 grains.

Crocus (U.S.P. 1890; N.F. IV) or *saffron* is interesting as one of the most expensive of vegetable drugs, its great cost being due to the labor of collection. The definition of the drug is "the stigmas of *Crocus sativus*," by which is meant the upper portion of the female organ of the flower.

On taking an Easter lily or Bermuda lily and slicing lengthwise the white funnel-shaped petal group (called the perianth) and removing it, all the interior organs are removed save the large central club-shaped column. This is the pistil or female organ, and this consists of three parts: First, the ovary at the base, which, on being sliced, shows the ovules which develop into seeds; second, the style or slender tube, terminating in, third, a disc-like triple-divided stigma designed to hold the pollen by which the ovary is fertilized.

In saffron, the stigma, instead of being a flat disc like that of the lily, consists of three delicate threads, and these constitute the official drug, to obtain a pound of which necessitates the picking of stigmas of about 150,000 flowers, and that by hand. Hence, it is easy to understand why saffron is so expensive and why so largely adulterated, the chief adulterant being the shredded petals of other flowers. The chief use of saffron is in domestic practice—for measles—and in cooking.

Saffron contains three crystalline bodies, one of which hydrolyzes to the volatile oil. Its characteristic color is due to a glucosidal pigment called *crocin*, which hydrolyzes to *crocetin* and a carbohydrate, *crocose*.

Convallaria Radix (U.S.P. VIII; N.F. IV) or *lily-of-the-valley root* is the dried rhizome and roots of *Convallaria majalis* Linné (Fam. *Liliaceæ*). It contains *convallarin*, a glucoside, *convallamarin*, a saponin. It slows and strengthens heart-beat, as does digitalis. Its dose is 8 grains. Convallaria flowers are also recognized by the Formulary.

STROPHANTHUS—Strophanthus

(Strophanth.)

The dried, ripe seeds of *Strophanthus Kombe* Oliver, or of *Strophanthus hispidus* De Candolle (Fam. *Apocynaceæ*), deprived of the long awns. If made into the official tincture and assayed biologically the minimum lethal dose should not be greater than 0.00006 mil of tincture, or the equivalent in tincture of 0.0000005 Gm. of ouabain, for each gramme of body weight of frog. Preserve Strophanthus in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—*Strophanthin,* a glucoside, *kombic acid,* a fixed oil, etc.

Remarks.—The "awn" referred to in the official definition is a feather-like appendage to the seed, intended to aid in transportation of the seed by the wind.

The fixed oil is a source of annoyance to the pharmacist, as a tincture made with strong alcohol becomes milky when mixed with water. For this reason the official tincture is made by first percolating the drug with benzin to remove the fat before percolating with the real menstruum, alcohol.

Medical Properties.—Acts on the heart as does digitalis.

Dose.—65 milligrammes (1 grain).

STROPHANTHINUM—Strophanthin

(Strophanthin.)

A glucoside or mixture of glucosides obtained from *Strophanthus Kombe* Oliver (Fam. *Apocynaceæ*). Preserve it in well-closed containers, protected from light.

Summarized Description.

White or yellowish powder; very toxic; very soluble in water and in diluted alcohol; less soluble in dehydrated alcohol; insoluble in chloroform, ether and benzene; dextrorotatory. For details see U.S.P., p. 414.

Color Reactions.—Emerald-green color with sulphuric acid; red-brown, then dark-green with ferric chloride and sulphuric acid. See U.S.P.

Extraction.—Strophanthin is obtained by extracting the fat-free pulverized seeds with 70 per cent. alcohol, and removing the alcohol from the tincture by distillation. The thin extract after a few days deposits crystals of strophanthin, which after collection on a hardened filter and after recrystallization from boiling water yields a pure product.

It will be seen from the above definition that it is a question whether strophanthin is a definite body or a mixture. It is used like strophanthus, but in very minute doses.

Dose.—3/10 milligramme (1/200 grain).

SCILLA—Squill

(Scill.)

The fleshy, inner scales of the bulb of the white variety of *Urginea maritima* (Linné) Baker (Fam. *Liliaceæ*), cut into pieces and carefully dried. Preserve Squill in tightly closed containers, in a dry place. If made into the official tincture and assayed biologically the minimum lethal dose should not be greater than 0.006 mil of tincture or the equivalent in tincture of 0.0000005 Gm. of ouabain, for each gramme of body-weight of frog.

Constituents.—Scillitin $C_{17}H_{25}O_6$ and scillidiuretin. Scillipicrin and scillitoxin are now known to be mixtures. Squill contains calcium oxalate in peculiar-shaped crystals called *raphides,* and also mucilage.

Remarks.—While squill is used as a domestic remedy, it must be borne in mind that its active principles have action on the heart similar to digitalis. Hence squill preparations should be used with caution. By reason of the irritating action of its calcium oxalate crystals, ground squill has been recommended as a rat poison.

Medical Properties.—Nauseant, expectorant, and diuretic.

Official Preparations.—The *vinegar* (p. 255), the *syrup* (made from the vinegar) (p. 199), the *fluidextract* (p. 248), and the ***compound syrup,*** which is made from the fluidextract (p. 200).

Dose.—100 milligrammes (1½ grains).

DIGITALIS—Digitalis

(Digit.—Foxglove—Digitalis folium P. I.)

The carefully dried leaves of *Digitalis purpurea* Linné (Fam. *Scrophulariaceæ*) without admixture of more than 2 per cent. of stems, flowers, and other foreign matter. If made into the official tincture and assayed biologically the minimum lethal dose should not be greater than 0.006 mil of tincture, or the equivalent in tincture of 0.0000005 Gm. of ouabain, for each gramme of body weight of the frog. Digitalis should be preserved in tightly closed containers protected from light.

Constituents.—Digitonin (a saponin), *digitalin,* (a glucoside), *digitalein* (mixture of several bodies, chiefly digitonin), *digitoxin,* digitophyllin, digitin, digitoflavin, 5 per cent. fat, and a trace of substance darkening with ferric chloride. Of these, the first four are the only ones of therapeutic importance, and, in truth, the real activity of digitalis seems included in the two principles—digitalin, the cardiac stimulant, and digitonin, depressant and diuretic.

Remarks.—There has been no drug concerning which there have been more conflicting opinions expressed during the past decade than digitalis. In fact, about the only fact upon which all observers agree is that it is one of the most valuable drugs in our materia medica. Among the points concerning which opinion has changed we find that while it was for many years thought that digitalis leaves collected from a plant two years old were better than those picked from a young plant, Worth Hale has shown by physiological tests that the first year leaves have as much activity as have those from the two-year old plant. Again it was supposed that the plucked leaves deteriorated quickly and in some of the foreign pharmacopœias elaborate directions are given for drying the fresh leaves and for keeping the desiccated leaves dry. Hatcher has recently shown however that old indifferently preserved leaves have as much activity as have those which have been carefully dried. It has also been shown that there is little difference in the activity of wild and cultivated leaves.

When we turn to the chemistry of digitalis, the situation is still more confusing. Thus while the constituents cited above are generally accepted, Kraft claims that the activity resides in five glucosides, to which unfortunately he gives names other than those of Kiliani enumerated above.

It will be seen from the mention of the constituents given above that the chemistry of digitalis is very complex, and is not yet fully cleared up. The confusion is particularly noted in the various digitalins found in the market—the so-called "French digitalin." of Nativelle; that of Homolle; and the commercial "German digitalin," being totally different bodies. The last consists practically of digitonin, and is of but little activity (dose, 1/10 to ½ grain); while Homolle's is quite potent (dose, 1/200 to 1/40 grain). Digitoxin is now considered a more important heart tonic than the several digitalins just described (dose, $\frac{1}{240}$ to $\frac{1}{60}$ grain). The confusion of these digitalins is apt to lead to dangerous results, and until the question is definitely settled on a basis of scientific exactness, the prescribing of digitalin is not to be advised.

The difficulty in selecting digitalis of uniform quality is enhanced by the fact that there is no reliable chemical assay for the drug. Recourse is, therefore, had to a "*physiologic assay*," and as this is the first drug considered in this book where such assay is used, a few words explanatory of such assays may be of service. Physiologic assays are those in which the activity of the drug is tested upon animals, and in each case where employed the method of procedure varies with the drug under consideration. Thus, digitalis is usually tried on frogs, the amount necessary to stop the heart being taken as the factor. Ergot is given to roosters, the quantity needed to produce a certain purple tint of the comb being the gage of activity. Of course, the tests are far more complex than this scant explanation implies, for example, other factors, such as weight of animal, enter into the calculation leading to standardization. In fact, physiologic testing is beyond the scope of the average pharmaceutic chemist, and for this reason, as well as the fact that the process is not on the same basis of exactness as are chemical assays, the present pharmacopœia, while it provides physiologic assays (see Part V), does not make them compulsory.

When we turn to the subject of the pharmaceutical preparations, we find more doubts. As mentioned above it was formerly considered that the heart tonic effect was due to digitalin, which was found in larger amounts in the tincture than in the infusion; while the diuretic action was due to digitonin, which was exhibited in the best form in the infusion. At present, however, there are serious doubts as whether there is any material difference in the action of the tincture and the infusion. Digitalis is a constituent of the official infusion (p. 217); tincture (p. 226), and fluidextract (p. 244).

Medical Properties.—A "cardiac tonic," that is, it slows and strengthens the heart-beat and constricts the blood-vessels. Of peculiar value in dropsy because of its diuretic action.

Dose.—6 milligrammes (1 grain).

Lappa (U.S.P. VIII; N.F. IV) or *burdock root* is the dried root of *Arctium Lappa* Linné, or of other species of *Arctium* (Fam. *Compositæ*), collected from plants of the first year's growth. It is supposed to contain a glucoside, of which but little is known, also mucilage and inulin. Note that the roots of plants of the natural odor Compositæ usually contain inulin (p. 633) instead of starch. The phrase "from plants of the first year's growth" employed above means that the plant, like digitalis, is a biennial and that the root is collected in the fall of the first year, when filled with the inulin, destined to serve as nourishment for the young shoots of the second year. Lappa is used as a purgative in 30-grain doses.

JALAPA—Jalap

(Jalap.)

The dried tuberous root of *Exogonium Purga* (Wenderoth) Bentham (Fam. *Convolvulaceæ*), yielding not less than 7 per cent. of the total resins of Jalap.

Outline of Assay.—Percolate the drug with alcohol; mix the percolate with chloroform and then with water, separate the chloroform layer and shake out with another portion of chloroform. Evaporate the chloroform extract and weigh. For details see U.S.P., p. 230.

Constituents—Resin, consisting chiefly of two glucosides, *jalapin* (ether soluble) and *convolvulin* (insoluble in ether); *sugar*, *starch*, etc.

Power and Rogerson have found that resin of jalap contains fatty acids, a phytosterol $C_{27}H_{46}O$, cetyl alcohol, a body $C_{18}H_{36}O$, a glucoside ipurganol $C_{21}H_{32}O_2(OH)_2$, methyl esculetin, and convolvulinic acid, $C_{15}H_{30}O_3$. The glucosides mentioned above are combinations of the substances just stated. Votocek, on the other hand, claims that convolvulin is a glucoside hydrolyzing to methyl-ethyl acetic acid, convolvulic acid and purginic acid. Convolvulic acid, in turn hydrolyzes to convolvulolic acid, dextrose, rhodeose and rhamnose; while purginic acid is supposed to split into decylenic acid hydroxylauric acid and iso-rhodeose. Before such conflicting views, the average student can only stand in awe.

Remarks.—Jalap is a tuberous root, similar to the sweet potato, and belonging to the same family—the convolvulus or morning-glory family. In the former pharmacopœia it was directed that jalap should yield no more than 1.05 per cent. of ether-soluble resin (jalapin) and not less than 5.95 of ether-insoluble resin (convolvulin)—that is, while the drug must yield not less than 7 per cent. total resin, the amount of ether-soluble resin should not be not more than 1.05 per cent. This requirement was made because jalapin is nauseating, and it has been recommended that jalap be used only after the jalapin has been removed by percolation with ether.

Medical Properties.—Hydragogue cathartic, that is, a drug producing watery stools. It is administered as *resin* (p. 282), which is a constituent of compound cathartic pills (p. 312), and as *compound powder of jalap* (p. 293), the cream of tartar which the latter contains greatly aiding the action of the jalap.

Dose.—1 gramme (15 grains).

SCAMMONII RADIX—Scammony Root

(Scam. Rad.)

The dried root of *Convolvulus Scammonia* Linné (Fam. *Convolvulaceæ*), yielding not less than 8 per cent. of the total resins of Scammony Root.

Constituents.—Resin, gum, etc.

Remarks.—While scammony resin was official in the last pharmacopœia, in the present (ninth) revision, the root is given recognition. This must contain not less than 8 per cent. of resin. This resin, is chiefly scammonin which is identical with the jalapin from Orizaba jalap (*Ipomœa orizabensis*), but is not the same as the jalapin from official jalap.

Medical Properties.—Hydragogue cathartic. The resin (p. 283) is official, and this a constituent of compound extract of colocynth (p. 275).

Dose.—250 milligrammes (4 grains).

COLOCYNTHIS—Colocynth

(**Colocyn.**—Colocynth Pulp. Bitter Apple—Colocynth Apple)

The dried pulp of the fruit of *Citrullus Colocynthis* (Linné) Schrader (Fam. *Cucurbitaceæ*), without admixture of more than 5 per cent. of seeds nor more than 2 per cent. of epicarp.

Constituents.—Two purgative resins, *citrullol*, $C_{22}H_{36}O_2(OH)_2$ (inactive); *hentriacontane*, $C_{31}H_{64}$, *a phytosterol*, $C_{27}H_{46}O$.

Remarks.—The colocynth pulp now official is practically the colocynth apple of the former pharmacopœia except for the fact that the percentage of seed and of epicarp (or rind) is carefully specified. It moreover should not yield more than 15 per cent. of ash.

Medical Properties.—Hydragogue cathartic. Official preparations, *extract* and *compound extract* (p. 275).

Dose.—60 milligrammes(1 grain).

UVA URSI—Uva Ursi

(Bearberry)

The dried leaves of *Arctostaphylos Uva-ursi* (Linné) Sprengel (Fam. *Ericaceæ*), without the presence or admixture of more than 5 per cent. of stems or other foreign matter.

Constituents.—Arbutin, a glucoside (originally called *ursin*), *ericolin,* a glucoside; *ursone,* tannic and gallic acids, gum, etc. Arbutin is of interest since it has been made synthetically from its hydrolysis products. (See p. 640.)

Remarks.—It might be metioned in passing that the Greek name of the plant (arctostaphylus), and the Latin (and specific) name (uva ursi) both mean the same thing; namely, *bearberry,* which is the English synonym.

Medical Properties.—Astringent diuretic; antiseptic to the urinary passages. The fluidextract (p. 245) is official.

Dose.—2 grammes (30 grains).

Chimaphila (U.S.P. VIII; N.F. IV) or *pipsissewa* is the dried leaves of *Chimaphila umbellata* (Linné) Nuttall (Fam. *Ericaceæ*). It contains chimaphilin, $C_{24}H_{21}O_4$ and another *glucoside,* $C_{10}H_9O$. These two bodies are not clearly known, but it may be stated that the constituents of the drug are very similar to uva ursi. It is used like the latter drug in 30-grain doses.

Quillaja (U.S.P. VIII; N.F. IV) or *soap-bark* is the dried bark of *Quillaja Saponaria* Molina (Fam. *Rosaceæ,* deprived of the periderm. It is the first of the "saponinoid" drugs to be considered—drugs containing saponin, an acrid principle which froths in water like soapsuds. All liquid preparations of such drugs froth when agitated. Soap-bark is used more for washing colored silk (white fabrics are stained brown yellow by its decoctions) than for pharmaceutic purposes. It is, however, used in making emulsions, for which it would be excellent were it not dangerous on account of its irritating properties.

"Gum foam" used in soda water syrups is a preparation of soap-bark. The use of it and similar saponin preparations in beverages is now prohibited.

Ground soap-bark should be handled with care, as its dust is very irritating to the nostrils, producing violent sneezing. Such drugs are said to be sternutatory.

SARSAPARILLA—Sarsaparilla

(Sarsap.)

The dried root of *Smilax medica* Chamisso and Schlechtendal, known in commerce as Mexican Sarsaparilla; or *Smilax officinalis* Kunth, or an undetermined species of *Smilax,* known in commerce as Honduras Sarsaparilla; or *Smilax ornata* Hooker filius, known in commerce as Jamaica Sarsaparilla (Fam. *Liliaceæ*).

Constituents.—Parillin (a glucoside similar to saponin, originally called *pariglin; saponin; sarsasaponin;* starch, calcium oxalate in the form of raphides, etc.

According to Power and Salway, Jamaica sarsaparilla contains sarsasaponin $C_{44}H_{76}O_{20}7H_2O$ and *sitosterol glucoside* $C_{33}H_{56}O_6$. They consider parillin as a mixture of saponin and a phytosterolin.

Medical Properties.—Sarsaparilla is a drug whose reputation is chiefly false. It is vaunted to the skies by the numerous patent medicine men as the greatest of all blood purifiers, yet cold, calm analysis shows it to have but little merit. It contains saponinoid principles which cause it to froth, and possibly a trace of volatile oil, but neither of these can be regarded as great alteratives, and we are forced to the conclusion that its reputation has been gained by its association with other valuable alteratives. It is rarely prescribed by itself, its only simple official preparation being the *fluidextract* (p. 244), while its popular preparations are the compound syrup (p. 199) and *compound fluidextract* (p. 247), which contain such alteratives as guaiacum and mezereum, and, moreover, these preparations are usually prescribed with potassium iodide.

Dose.—2 grammes (30 grains).

SENEGA—Senega

(Seneg.—Seneca Snakeroot—Senega Snakeroot)

The dried roots of *Polygala Senega* (Linné (Fam. *Polygalaceæ*), without the presence or admixture of more than 5 per cent. of stems and other foreign matter.

Constituents.—*Senegin* or *polygalic acid* (a form of saponin); an acid also called polygalic acid; trace of volatile oil, pectin, etc. No starch nor tannin.

Remarks.—The pectin of senega is a source of annoyance in the pharmaceutic preparations of the drug, these gelatinizing or becoming cloudy on standing, due to conversion of the pectin into the insoluble calcium pectate. This decomposition is prevented by the addition of alkali; hence the official senega preparations contain ammonia water.

Medical Properties.—Expectorant, nauseant. Emetic in large doses.

Official Preparations.—*Fluidextract* (p. 248), and from this the *syrup* (p. 200) and *compound syrup of squill* (p. 200) are made.

Dose.—1 gramme (15 grains).

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CHAPTER XLI

DERIVATIVES OF THE HIGHER HYDROCARBONS

FATS, SOAPS, AND WAXES

As already mentioned, chain hydrocarbons containing more than six carbon atoms are known. Thus we have heptane, C_7H_{16}; octane, C_8H_{18}; nonane, C_9H_{20}; decane, $C_{10}H_{22}$, and likewise the bodies $C_{11}H_{24}$, $C_{12}H_{16}$, and so on to $C_{60}H_{122}$. None of the bodies just mentioned is of interest in pharmacy, save that petroleum contains variable amounts of almost all members of the series.

Of pharmaceutic value, however, are the derivatives of $C_{16}H_{34}$, $C_{18}H_{38}$ $C_{27}H_{56}$, $C_{30}H_{62}$, and of the unsaturated hydrobarbon, $C_{18}H_{36}$.

Hexadecane, $C_{16}H_{34}$, yields a series of alcohols having the formula $C_{16}H_{33}OH$. One of these hexadecyl alcohols is known as *cetyl alcohol* or *æthal*, and is interesting as the alcoholic part of the ester which is the chief constituent of spermaceti. Cetyl alcohol yields on oxidation *palmitic acid*, $C_{15}H_{31}COOH$, which is the common constituent of fats and waxes. Thus the cetin, mentioned above as the chief constituent of spermaceti, is the ester, *cetyl palmitate*.

Likewise the palmitate of glyceryl, commonly known as *palmitin*, is a common constituent of fats.

ACIDUM STEARICUM—Stearic Acid

(Acid Stear.)

An acid obtained from tallow and other fats consisting chiefly of $C_{18}H_{36}O_2$ or $C_{17}H_{35}\cdot COOH$ (284.29).

Summarized Description.

Hard white or yellowish-white, somewhat glossy, solid; odorless or faint tallow odor; soluble in about 17 parts of alcohol; insoluble in water; soluble in chloroform, ether, carbon disulphide or carbon tetrachloride; melts at not lower than 56°C. and congeals at not lower than 54°; ash, not more than 0.1 per cent. For details see U.S.P., p. 23.

For *tests for identity* and for *impurities:* Undecomposed fat or paraffin (hot solution in sodium carbonate solution not more than opalescent).

Mineral acids (hot aqueous extract not reddened by methyl orange), see U.S.P., p. 24 and also Part V of this book.

Remarks.—Stearic acid is one of the monobasic acids from $C_{18}H_{38}$. It is a white, waxy solid, insoluble in water, melting at 70°C. when pure. The commercial acid, however, has a much lower melting point. Its commercial source is from solid fats, such as tallow and suet, which, on treatment with superheated steam, yield glycerin and stearic acid. Hence most commercial stearic acid is a side-product in glycerin manufacture.

Tallow and suet are composed chiefly of stearin or the stearic acid ester of glycerin, and this, like all esters, can be easily decomposed by treatment with an alkali or with superheated steam by the following reaction.:

$$C_3H_5(C_{18}H_{35}O_2)_3 \ + \ \underset{\text{Steam}}{3H_2O} \ = \ C_3H_5(OH)_3 \ + \ 3HC_{18}H_{35}O_2.$$

At present, however, considerable stearic acid is made by the reduction or "hydrogenation" of oleic acid. (See p. 652.)

Stearic acid is official because it enters into the manufacture of glycerin suppositories, a very small quantity of stearic acid soap being ample to solidify a large quantity of glycerin.

Thus in the U.S.P. recipe 30 grammes of glycerin are solidified by heating with 2 grammes of stearic acid and 0.5 gramme of monohydrated sodium carbonate, the products of the reaction being glyceryl stearate and sodium stearate.

Margaric acid is a name applied to pearly scales isolated from some fats by Chevreul. Its analysis shows the formula $C_{16}H_{33}COOH$. There has been considerable controversy as to whether this acid really exists or whether it is merely a mixture of palmitic and stearic acid.

ACIDUM OLEICUM—Oleic Acid

(Acid. Oleic.)

An acid obtained from fats consisting chiefly of $C_{18}H_{34}O_2$ or $C_{17}H_{33}COOH$ (282.27). Preserve it in well-closed glass or stoneware containers, in a cool place.

Summarized Description.

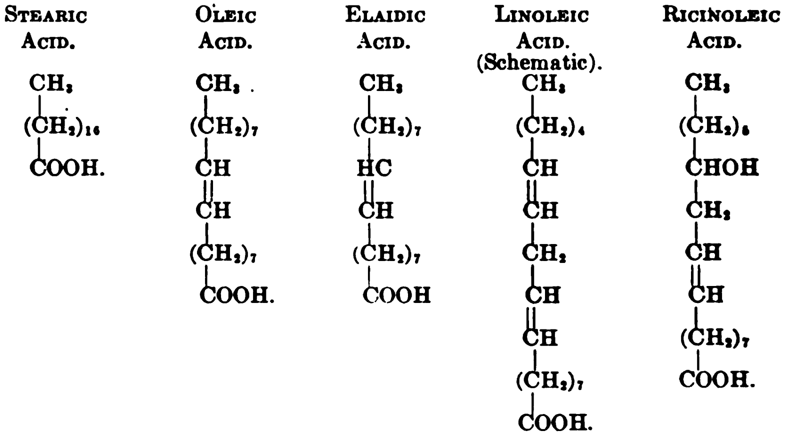
Yellowish or brownish-yellow oily liquid; peculiar lard-like odor and taste; free from rancidity; insoluble in water; partly soluble in 60 per cent. alcohol; soluble in alcohol, chloroform, benzene, petroleum benzin and in fixed and volatile oils; sp. gr. 0.895; congeals at about 4°C.; decomposes at about 95°C. For details see U.S.P., p. 20.

For *impurities:* (Undecomposed fats, mineral oil, mineral acids) see stearic acid.

Remarks.—Oleic acid is obtained from oils by treating same with superheated steam in the process of glycerin manufacture. For making oleates, one should employ a very pure form of oleic acid made by treating a solution of castile soap with diluted sulphuric acid.

Oleic acid is the product of unsaturated hydrocarbon $C_{16}H_{36}$, and, as can be noticed, it represents stearic acid minus two atoms of hydrogen.

The best comparison of this body with stearic acid and with other similar acids can be made by representing the structural formulas side by side:



STEARIC ACID. $CH_3-(CH_2)_{16}-COOH.$

OLEIC ACID. $CH_3-(CH_2)_7-CH=CH-(CH_2)_7-COOH.$

ELAIDIC ACID. $CH_3-(CH_2)_7-HC=CH-(CH_2)_7-COOH$

LINOLEIC ACID. (Schematic). $CH_3-(CH_2)_4-CH=CH-CH_2-CH=CH-(CH_2)_7-COOH.$

RICINOLEIC ACID. $CH_3-(CH_2)_5-CHOH-CH_2-CH=CH-(CH_2)_7-COOH.$

Oleic acid is a yellow or yellowish-brown, oily liquid, not affecting litmus-paper, and solidifying at 4°C.

On treatment with a large quantity of alcoholic potassium hydroxide it breaks into palmitic and oxalic acids, strong heat with nitric acid breaking it up into a number of simpler bodies; on the other hand, gentle heat with nitric acid converts it into the isomeric yellow solid *elaidic acid*, the graphic formula of which is given above. By treating oleic acid (or oleates) with hydrogen in the presence of a catalytic agent, like finely divided metallic nickel, solid stearic acid (or stearates) are formed.

Oleic acid is the chief constituent of liquid fats or oils in the form of the glycerin ester *olein*.

The oleic acid solutions of metallic oxides or alkaloids form the pharmaceutic class, oleates (p. 214).

Linoleic acid, $C_{17}H_{31}COOH$, differs from oleic acid by possessing two atoms of hydrogen less. It is, therefore, more unsaturated than oleic acid. In the form of glycerin ester it is the chief constituent of linseed oil, the drying properties of which render it so valuable in paint. Most oils spread on wood are absorbed by the fibers, leaving a permanent greasy stain; with linseed oil, on the other hand, the stain gradually becomes resinous, due to the oxidation of linolein into the product linoxyn. Very similar to it are the other acids of linseed oil, *linolenic acid* and *isolinolenic acid*. In fact, there still wages a controversy as to whether the last two are not merely impure forms of linoleic acid.

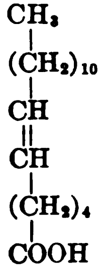
Ricinoleic acid, $C_{17}H_{32}OHCOOH$, represents oleic acid, in which one hydrogen has been replaced by a hydroxyl group. It, in the form of glycerin compound, is the chief constituent of castor oil. Ricinoleic acid forms a chemical combination with sulphuric acid, and the product which is generally obtained by direct treatment

of castor oil with sulphuric acid forms with potassa a jelly-like liquid which, on account of its excellent solvent powers, has been called "polysolve." It dissolves a variety of substances, as metallic salts, gums, resins, solid extracts, iodoform, and chrysarobin.

A variety of polysolve has been introduced into American pharmacy under the name *oleite*, as a vehicle for the external application of a variety of medicines.

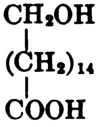
Other fat and wax acids are:

PETROSELENIC ACID.



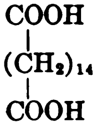
$CH_3-(CH_2)_{10}-CH=CH-(CH_2)_4-COOH$

JUNIPERIC ACID.



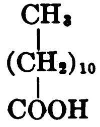
$CH_2OH-(CH_2)_{14}-COOH$

THAPSIC ACID.



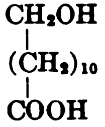
$COOH-(CH_2)_{14}-COOH$

LAURINIC ACID.



$CH_3-(CH_2)_{10}-COOH$

SABINIC ACID.



$CH_2OH-(CH_2)_{10}-COOH$

OILS AND FATS

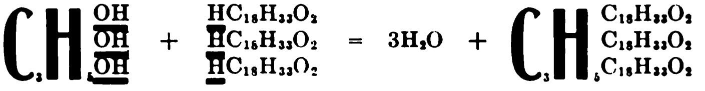
An oil is any liquid which greases—which leaves, when dropped on cloth, a stain which water will not wash out, a stain which makes paper translucent. If a solid substance exhibits similar properties, it is called a fat. Oils are called *volatile* or *fixed*, according as this stain disappears on warming or is permanent by reason of the non-volatility of the oil—characters clearly defined by the names given the two groups.

All fixed oils and fats are combinations of glycerin with oleic, stearic, palmitic, or analogous acids—are glycerin esters of these acids.

As already learned (p. 572), alcohols react with acids, just as do the inorganic basic hydroxides, and such products of alcohols called esters are analogous to the inorganic salts. Among examples of such ester formation already cited were:

$$C_2H_5OH + HNO_2 = H_2O + C_2H_5NO_2 \quad \text{Ethyl nitrite.}$$
$$C_2H_5OH + HC_2H_3O_2 = H_2O + C_2H_5C_2H_3O_2 \quad \text{Ethyl acetate.}$$

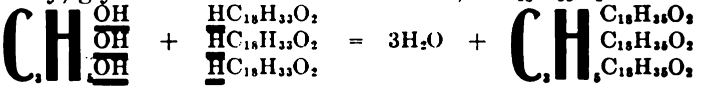
Similarly, glycerin reacts with acids forming esters. Thus, one molecule of glycerin, $C_3H_5(OH)_3$, reacts with three molecules of oleic acid, $HC_{18}H_{33}O_2$, as shown graphically below:



$$C_3H_5\begin{cases}OH\\OH\\OH\end{cases} + \begin{matrix}HC_{18}H_{33}O_2\\HC_{16}H_{33}O_2\\HC_{18}H_{33}O_2\end{matrix} = 3H_2O + C_3H_5\begin{cases}C_{18}H_{33}O_2\\C_{18}H_{33}O_2\\C_{18}H_{33}O_2\end{cases}$$

or $C_3H_5(C_{18}H_{33}O_2)_3$, glyceryl oleate or olein.

Similarly, glycerin reacts with stearic acid, $HC_{18}H_{35}O_2$:



$$C_3H_5\begin{cases}OH\\OH\\OH\end{cases} + \begin{matrix}HC_{18}H_{33}O_2\\HC_{18}H_{33}O_2\\HC_{18}H_{33}O_2\end{matrix} = 3H_2O + C_3H_5\begin{cases}C_{18}H_{35}O_2\\C_{18}H_{35}O_2\\C_{18}H_{35}O_2\end{cases}$$

or $C_3H_5(C_{18}H_{35}O_2)_3$, glyceryl stearate or stearin.

Combinations of varying proportions of glyceryl oleate (olein), glyceryl palmitate (palmitin), and glyceryl stearate (stearin) form the fixed oils and fats. The larger the proportion of olein, the more liquid is the fatty substance, oils like that from olives being largely olein. As the amount of stearin increases the more solid the fatty substance becomes, until, in tallow, there are little olein and much stearin.

Fats are now being called *lipins* and similar substances are denominated *lipoids*. Rosenboom and Gies have devised a scientific classification of these bodies. The first group consists of the true lipins, including what we call fatty acids, fats, oils, waxes and soap; the lipoids which are far more numerous and more complicated in structure, are classified as proteo-lipins, glyco-lipins, phospho-lipins, sterols, esterols, cholates, etc.

Fats and fatty oils and waxes are grouped by Allen as follows:

I. Olive oil group: Non-drying vegetable oleins. Examples, olive, almond, peanut, and mustard oils.

II. Cotton seed oil group: Intermediate between I. and III.; hence adulterants of both. Examples: Cotton seed, rape seed, beechnut, and sesame oils.

III. Linseed oil group: Containing linoleic acid, hence drying oils, becoming resinous on boiling with litharge. Examples: Linseed oil and a few others.

IV. Castor oil group: Containing ricinoleic and other acids. Examples: Castor, croton, and Japan wood oils.

V. Palm oil group: Semisolid fats. Examples: Palm, theobroma, and nutmeg oils.

VI. Coconut oil group: Solid esters of lauric acid ($C_{11}H_{23}COOH$). Easily saponified, hence valuable in soap-making. Example: Coconut oil.

VII. Lard oil group: Animal oleins. Examples: Lard, neatsfoot, and bone oils.

VIII. Tallow group: Solid animal fats. Examples: Tallow, lard, suint, and butter.

IX. Whale oil group: Marine animal oleins, mixed with glycerides of caproic and valerianic acids. Examples: Whale, porpoise, and cod liver oils.

X. Sperm oil group: Liquid waxes, being esters of monatomic alcohols; thus, sperm oil is the oleate of lauric alcohol, $C_{12}H_{25}OH$. Examples: Sperm, bottlenose, and dolphin oils.

XI. Spermaceti group: Waxes, esters of higher monatomic alcohols. Examples: Spermaceti, beeswax, and Japan wax.

OFFICIAL FIXED OILS AND FATS

OLEUM OLIVÆ—Olive Oil

(Ol. Oliv.)

A fixed oil obtained from the ripe fruit of *Olea europæa* Linné (Fam. *Oleaceæ*). Preserve it in well-closed containers, in a cool place.

Summarized Description.

Pale-yellow or greenish-yellow oily liquid; slight peculiar odor and taste; slightly soluble in alcohol; miscible with ether, chloroform or carbon disulphide; sp. gr. 0.910 to 0.915; becomes cloudy at 8° to 10°C. and congeals at 0°. For details see U.S.P., p. 298.

For *tests for identity* and for *impurities:* Cotton seed oil (no red color on being heated in a salt-water bath with a mixture of amyl alcohol and carbon disulphide containing sulphur).

Sesame oil (no pink color when shaken into hydrochloric acid containing sugar and then with water) see U.S.P., p. 298 and also Part V of this book.

Saponification Number.—190 to 195. Details in Part V.

Iodine Absorption Number.—79 to 90. Details in Part V.

Composition.—Olein, 67 per cent.; palmitin, 28 per cent.; linolein, 5 per cent.

Remarks.—Olive oil is obtained by expressing the ripe olive, the same fruit which, when green and pickled, forms the familiar table relish.

Formerly olive oil was largely adulterated with cotton seed oil, but two tests have been devised which can unerringly detect this sophistication. One of these is the Halphen test, the red tint produced when cotton seed oil or its mixtures is digested with a reagent consisting of solution of sulphur in amyl alcohol and carbon disulphide. The other is Becchi's test, which is based upon the blackening of an alcoholic solution of silver nitrate when it is heated on a water-bath with cotton seed oil or its mixtures.

Thanks to these two tests and to the rigid scrutiny of food officials most of the olive oil at present in the American market is pure. It might be well to point out that under food decision 139, *sweet oil* means olive oil only.

The last two tests given—the *saponification number* and the *iodine absorption number*—are of great importance in establishing the constants for all fixed oils.

As, however, a clear understanding of the two tests implies a comprehension of the theory of volumetric analysis, explanation of the tests will be left for the chapter on Pharmaceutic Testing (pp. 913–915).

Medical Properties.—Laxative and emollient, externally in liniments.

Dose.—30 mils (1 fluidounce).

OLEUM AMYGDALÆ EXPRESSUM—Expressed Oil of Almond

(**Ol. Amygd. Exp.**—Oil of Sweet Almond)

A fixed oil obtained from the kernels of varieties of *Prunus Amygdalus* Stokes (Fam. *Rosaceæ*). Preserve it in well-closed containers, in a cool place.

Summarized Description.

Clear pale straw-colored oily liquid; bland taste; slightly soluble in alcohol; miscible with ether, chloroform, benzene or petroleum benzin, sp. gr. 0.910 to 0.915. For details see U.S.P., p. 286.

For *tests for identity*, for *impurities:* Olive or lard oil (does not congeal until cooled to —20°C.). Peach kernel, apricot kernel, sesame or cotton seed oil (shaken with nitric acid and water under proper conditions, does not turn red or brown). Paraffin oil (forms a soluble soap with sodium hydroxide and alcohol). Foreign oils (this soap, when dissolved in water and treated with hydrochloric acid yields an oleic acid, which remains clear at 15°C.). Olive, arachis, cotton seed, sesame and other fixed oils (this oleic acid forms a clear alcoholic solution even at 15°C.). See U.S.P., p. 286.

Saponification Number.—191 to 200. Details in Part V.

Iodine Absorption Number.—93 to 100. Details in Part V.

Composition.—Olein, 76 per cent., stearin and palmitin.

Remarks.—The sources of this oil will be studied in other places. Sweet almond in this chapter (p. 663) and bitter almond in Chapter XLIII (p. 705). A large amount of the commercial oil of sweet almond is, in reality, the fixed oil expressed from peach and apricot kernels, and in the official data given above will be found a test for distinguishing the true oil from these substitutes.

Medical Properties.—Demulcent and laxative. Used in cold cream (p. 331), and emulsion of oil of turpentine (p. 263).

OLEUM SESAMI—Sesame Oil

(**Ol. Sesam.**—Teel Oil. Benne Oil)

A fixed oil obtained from the seeds of one or more cultivated varieties of *Sesamum indicum* Linné (Fam. *Pedaliaceæ*). Preserve it in well-closed containers.

Summarized Description.

Pale-yellow oily liquid; bland taste; slightly soluble in alcohol; miscible with chloroform, ether, petroleum benzin or carbon disulphide, sp. gr. 0.916 to 0.921. For details see U.S.P., p. 301.

For *tests for identity*, for *impurities:* Free acid (litmus test) see U.S.P. Cotton seed oil (Halphens test.)

Saponification Number.—188 to 193. Details in Part V.

Iodine Absorption Number.—103 to 112. Details in Part V.

Composition.—Solid acids, 12 to 14 per cent.; liquid acids (oleic and linoleic),78 per cent.; glycerin.

Remarks.—This oil, re-introduced into the pharmacopœia after several decades of absence, is now official since it is found to be the most satisfactory oil to use in making ammonia liniment. The test for identity of this oil given in the pharmacopœia, the red color produced by treating the oil with hydrochloric acid containing sugar, was devised by Badouin and is useful for detecting the presence of the oil as an adulterant of olive oil.

OLEUM GOSSYPII SEMINIS—Cottonseed Oil

(Ol. Gossyp. Sem.—Cotton Seed Oil)

A fixed oil obtained from seeds of cultivated varieties of *Gossypium herbaceum* Linné, or of other species of *Gossypium* (Fam. *Malvaceæ*). Preserve it in well-closed containers.

Summarized Description.

Pale-yellow oily liquid; bland taste; slightly soluble in alcohol; miscible with ether, chloroform, petroleum benzin and carbon disulphide, sp. gr. 0.915 to 0.921; becomes turbid at 12°C.; congeals at 0° to −5°C. For details see U.S.P., p. 293.

For *tests for identity*, see U.S.P.

Saponification Number.—190 to 198. Details in Part V.

Iodine Absorption Number.—105 to 114. Details in Part V.

Composition.—Olein, palmitin, linolein and a small amount of the glyceride of linolenic acid.

Remarks.—Cotton seed oil, like all other fixed oils, should be "cold pressed," that is, the expression of the oil from the seed should be done between the *cold* plates of a hydraulic press (p. 157). In order to increase the output of their product, oil-pressers frequently express the seed between heated plates, in which event the oil contains not only the liquid fats (olein), but also the solid fats, which are fused by the heated plates. Such an oil is a limpid liquid in warm weather, but on cool days it becomes cloudy and unsightly, and its filtration is a tedious task.

Any pharmacist who has regard for his reputation will carefully avoid use of such an oil in making official liniment of camphor (p. 265). Whether an oil is cold pressed or hot pressed can be easily tested by a small vial of it to a cool temperature. It must be borne in mind, however, that the official oil will turn cloudy at a temperature of 12°C.; hence in applying the above test the temperature should not be below that figure.

The conversion of cotton seed oil to an orange semisolid mass by heating with nitric acid in a water-bath constitutes the *elaidin reaction*. That is, the olein (glyceryl oleate) of the oil is changed into elaidin, the glycerin ester of elaidic acid, described on p. 652. The same reaction takes place with most fixed oils and fats, notably with lard oil and lard, and has pharmaceutic application in the latter case in the manufacture of citrine ointment.

As mentioned on p. 654, cotton seed oil has been largely used as an adulterant of olive oil.

As far as health is concerned, it is as good as olive oil, and it seems absurd to pay large prices for it simply because of its trip to Italy and its return in an olive-oil bottle. To do away with this sham as much as possible, the pharmacopœia has directed its use in many preparations formerly calling for olive oil. It is thus used in making *camphorated oil* (p. 265).

Medical Properties.—Demulcent and laxative.

OLEUM LINI—Linseed Oil

(Ol. Lini—Oil of Flaxseed—Raw Linseed Oil)

A fixed oil obtained from Linseed. Preserve it in well-stoppered containers. inseed Oil which has been "boiled" must not be used nor dispensed.

ummarized Description.

Yellowish oily liquid; peculiar odor; bland taste; thickens on exposure to air; ightly soluble in alcohol; miscible with ether, chloroform, petroleum benzin, carbon isulphide or oil of turpentine; sp. gr. 0.925 to 0.935. For details see U.S.P., p. 295.

For *tests for identity*, for *impurities:* Free acid (litmus test). Non-drying oils esinifies when spread in thin layer on glass plate). Mineral or rosin oils. (Makes ater-soluble soap with potassium hydroxide and alcohol.) Rosin (a green, not iolet, color on treating with glacial acetic acid and sulphuric acid. (See U.S.P.)

Saponification Number.—187 to 195. Details in Part V.

Iodine Absorption Number.—Not less than 170. Details in Part V.

Composition.—Glycerides of linoleic acid, linolenic acid, and iso-linonic acid. (See p. 652.)

Remarks.—The official oil is what is commercially termed "raw il;" that is, the oil just as it emerges from the press. For painting urposes the raw oil is cooked with litharge, thereby enchancing its drying" qualities. Such oil is called "boiled oil," and the pharmaopœial definition given above gives special warning against the use f such boiled oil in medicine. As the boiled oil is more important in ommerce than the raw oil, the pharmacist should be sure to specify raw oil" in buying.

Linseed oil is a "drying oil." It contains, instead of olein, a similar ody, *linolein*, which, however, differs from the former by oxidizing to solid, *linoxyn*. Hence on being dropped or spread on a board, it ventually hardens into a protective surface, and, accordingly, it and the ther drying oils are of value in painting; for which purposes the non-lrying oils are unfitted.

It will be noticed among the tests for linseed oil given above that inseed oil is adulterated with mineral oils (various grades of refined etroleum) and with rosin or *rosin oil;* the latter, the product of the lestructive distillation of rosin, is rapidly becoming an important article f commerce.

Medical Properties.—Demulcent and laxative. A constituent of *carron oil* (p. 667).

Dose.—30 mils (1 fluidounce).

OLEUM RICINI—Castor Oil

(Ol. Ricin.)

A fixed oil obtained from the seeds of *Ricinus communis* Linné (Fam. *Euphorbiaceæ*) Preserve it in well-closed containers.

Summarized Description.

Pale yellowish or almost colorless transparent viscid liquid; faint mild odor; bland, then acrid then nauseating taste; miscible with dehydrated alcohol and with glacial acetic acid; sp. gr. 0.945 to 0.965. For details see U.S.P., p. 299.

For *tests for identity*, for *impurities:* Other fixed oils (only partly soluble in petroleum benzin; completely soluble in an equal volume of alcohol. (See U.S.P.)

Saponification Number.—179 to 185. Details in Part V.

Iodine Absorption Number.—83 to 88. Details in Part V.

Composition.—Note that the olein of this oil is the glyceryl ester of icinoleic acid (p. 652).

Remarks.—Castor oil is one of the few fixed oils which is freely soluble in official alcohol. For this reason it is useful as the greasy constituent of hair-lotions.

Medical Properties.—Valuable purgative. The only drawback to the administration of the oil is the disgust it usually excites, hence a disguised form is often demanded. The best method of administration is in sarsaparilla soda-water, the following points being carefully executed. First, put about fifteen drops of compound tincture of cardamom in a clean dry glass, twisting the glass so that its complete interior is moistened with this aromatic. Then add an ounce of regular soda fountain sarsaparilla syrup and squirt in the soda-water with the fine stream. Of course, this will produce a large amount of foam, and at this juncture pour in the dose of oil, carefully avoiding contact with the sides of the glass. Thus poured in, the oil will float between the bottom layer of the sarsaparilla soda and the foam on top, and, as the mixture is swallowed, the foam first and the soda-water last, convey to the tongue and the palate so decided a flavor that the oil slips down almost unnoticed. The compound tincture of cardamom is an essential, as it not only serves to keep the oil from sticking to the glass, but, moreover, by its aromatic odor and taste, does much in disguising the disagreeable odor and taste of the oil.

Castor oil can be solidified by the trituration of an equal amount of magnesium oxide. That the product is not a soap is shown by the fact that most of the oil can be extracted from the powder by treatment with ether. The oil can also be solidified by 78 parts of it with 22 parts of allophan. The product however is a chemical combination of the two ingredients. The magnesia type of *solid castor oil,* has recently become quite popular.

Dose.—15 mils (4 fluidrachms).

The so-called "castor oil capsules"—that is, the small ones of hard gelatin holding about 15 minims—are not to be recommended, as their purgative action is due to substances added to the castor oil, such as croton oil or podophyllin.

Aromatic Castor Oil (N.F.) consists of the oil flavored with an alcoholic solution of oils of cinnamon and clove, vanillin and cumarin, in which benzosulphinide (saccharin) is also dissolved as a sweetening agent.

OLEUM TIGLII—Croton Oil

Ol. Tiglii

A fixed oil expressed from the seeds of *Croton Tiglium* Linné (Fam. *Euphorbiaceæ*). Preserve it in small, well-stoppered bottles, protected from light.

Summarized Description.

Pale-yellow or brownish-yellow, somewhat viscid, slightly fluorescent liquid; slight fatty odor; acrid burning taste; very irritating to the skin; sp. gr. 0.935 to 0.950; soluble in 55 to 60 parts of alcohol; more soluble in alcohol, when old; miscible with ether, chloroform, and fixed and volatile oils. For details see U.S.P., p. 305.

Saponification Number.—200–215. Details in Part V.

Iodine Absorption Number.—104 to 110. Details in Part V.

Composition.—Glycerides of tiglinic (methyl-crotonic), acetic, butyric, valerianic, stearic, palmitic, laurinic, myristic, crotonic, oleic, and formic acids. A resin-like blistering substance, *crotonol*, $C_{19}H_{14}O_2$.

Medical Properties.—A powerful purgative, used only in cases of last resort, when all other purgatives have failed, its action being too violent for general use. It is a vesicant, producing blisters on application to the skin.

It is usually administered internally in the form of pills, the oil being solidified by use of crumb of bread.

Dose.—$\frac{1}{20}$ mil (1 minim).

OLEUM THEOBROMATIS—Oil of Theobroma

(Ol. Theobrom.—Butter of Cacao—Cacao Butter)

A concrete, fixed oil obtained from the roasted seeds of *Theobroma Cacao* Linné (Fam. *Sterculiaceæ*).

Summarized Description.

Yellowish-white solid; faint agreeable odor; bland chlocolate-like taste; slightly soluble in alcohol; more so in dehydrated alcohol; freely soluble in ether, chloroform or benzene; sp. gr. 0.973; melts between 30 and 35°C. For details see U.S.P., p. 304.

For *tests for identity* and for *impurities;* wax, stearin or tallow (ethereal solution on chilling does not readily become turbid), see U.S.P., p. 304.

Saponification Number.—188 to 195. Details in Part V.

Iodine Absorption Number.—33 to 38. Details in Part V.

Composition.—Glycerides of oleic, lauric, palmitic, stearic, and arachic acids. Matthes and Rhodich also found a phytosterin consisting of amyrilene and two true phytosterins.

Remarks.—Oil of theobroma is, chemically and physically, just between the oils and fats. While a hard solid at ordinary temperatures, the heat of the body is sufficient to melt it—to convert it to a liquid. This valuable property suggested to Duhamel in 1842 its use as a basis for suppositories, every other fat melting at so low a temperature being a soft, sticky mass at ordinary temperatures.

Note that the common term "cocoa-butter" is replaced in the pharmacopœia by the more accurate "butter of cacao" (the latter word being pronounced as if spelled "ka-ka-o"). This step relieves the confusion arising from the fact that three different plants have been given very similar names. These plants and products are:

Cacao (cocoa) and butter of cacao from *Theobroma Cacao,* the chocolate plant.

Coconut, from *Cocis nucifera,* the coconut palm.

Coca leaves, from *Erythroxylon Coca,* the coca shrub.

Hence the necessity of learning to say "cacao," for otherwise one is sure to confound the plant yielding chocolate and oil of theobroma with the coconut palm or with the coca tree.

Medical Uses.—Suppository base. Emollient for chapped hands.

Oleum Adipis (U.S.P. VIII), or *lard oil,* is a fixed oil expressed from lard at a low temperature. Instead of calling it, as in the case of castor oil, "cold pressed," this cold pressed lard oil is called in commerce "*winter strained,*" the two terms meaning practically the same thing. It consists of olein, some linolein, stearin and palmitin, the amount of solid constituents varying from very little in the best "winter strained" oil to much when the oil has been carelessly pressed.

Lard oil, like linseed oil, is largely adulterated with various petroleum oils. It was chiefly the presence of these mineral oils that made difficult the manufacture of citrine ointment from lard oil, as directed by U.S.P. 1890, and for this reason the ointment of present pharmacopœia is made from lard.

OLEUM MORRHUÆ—Cod Liver Oil

(Ol. Morrh.—Oleum Jecoris Aselli)

A fixed oil obtained from the fresh livers of *Gadus morrhua* Linné and of other species of *Gadus* (Fam. *Gadidæ*). Preserve it in a cool place, in well-closed containers, which have been thoroughly dried before filling.

Summarized Description.

Pale-yellow thin oily liquid; peculiar slightly fishy non-rancid odor; fishy taste; slightly soluble in alcohol; soluble in ether, chloroform, carbon disulphide or ethyl acetate; sp. gr. 0.918 to 0.922. For details see U.S.P., p. 297.

For *tests for identity*, for *impurities*: Seal oil and other fish oils (gives rose-red color with nitric acid). Free fatty acids (litmus test), see U.S.P.

Saponification Number.—180 to 190. Details in Part V.

Iodine Absorption Number.—140 to 180. Details in Part V.

Manufacture.—The oil is separated from fresh livers either by exposing to sun, when oil exudes; by slowly heating on steam bath; or by boiling with water and skimming off the separated oil.

Composition.—Olein, little palmitin and stearin, unsaturated fatty acids, traces bromides and iodides, cholesterin, and some animal decomposition products (alkaloids).

Remarks.—The best grade of cod liver oil is that obtained from the fisheries on the coast of Norway, although some grades of Newfoundland oil are of fair quality. The commercial oil is frequently adulterated with other fish oils; hence the nitric acid color test provided by the pharmacopœia. The keeping of cod liver oil deserves more care than is usually bestowed upon it by the pharmacist, hence the pharmacopœial injunction as to storing should be followed unless the druggist is willing to dispense a rankly smelling and tasting, partly decomposed product.

The efforts of some manufacturers to dispense a cod liver oil product minus the oil, such as the numerous wines of cod liver oil, is an example of the play Hamlet with the hero Hamlet omitted; for it is now considered by therapeutists that the medicinal value of the oil is due to the unsaturated fatty acids that it contains, and that the so-called "active principles," variously called *gaduol*, *morrhuol*, etc., are worse than useless. These substances usually are extracts prepared by shaking the oil with alcohol, separating the alcoholic layer, and distilling off the solvent, and when redissolved in aromatized alcoholic liquors, form the elixirs and wines of cod liver oil.

Medical Properties.—Demulcent, nutritive in wasting diseases. Best administered in the form of the official *emulsion* (p. 263).

Dose.—10 mils (2½ fluidrachms).

ADEPS—Lard

The purified internal fat of the abdomen of the hog (*Sus scrofa*, var. *domesticus* Gray, Fam. *Suidæ*). Preserve it in a cool place in well-closed containers which are impervious to fat.

Summarized Description.

Soft white unctuous solid; faint odor; bland taste; free from rancidity; insoluble in water; slightly soluble in alcohol; freely soluble in ether, chloroform, carbon disulphide and petroleum benzin; melts between 36° and 42°C. For details see U.S.P., p. 30.

For *tests for identity*, for *impurities* alkalies (boiled with water, the fluid is not alkaline).

Chlorides (silver nitrate test on the fluid just mentioned).

Free fatty acids (a modified volumetric test).

Cottonseed fats (Becchi's test), see U.S.P.

Composition.—Consists of the glycerides of lauric, myristic, palmitic, stearic, oleic and linoleic acids. The proportion of the acids are approximately 40 per cent. of solid acids, 50 per cent. of oleic acid and 10 per cent. of linoleic acid.

Remarks.—Note that, according to the rule laid down when discussing fats (p. 653), whether a fat is liquid or solid depends on the relative amount of olein and stearin it contains. Olive oil is almost pure olein; suet, which is hard, is almost pure stearin, while lard, which is half-and-half, is semisolid.

The solid fat of cotton seed oil is used for adulterating lard, and the pharmacopœial test for this impurity, is the *Becchi test* mentioned under olive oil. (See p. 654.)

Medical Properties.—Emollient and ointment base. Now used instead of lard oil in making citrine ointment (p. 560).

ADEPS BENZOINATUS—Benzoinated Lard

(Adeps Benz.)

Condensed Recipe.

Digest 1000 Gm. lard with 10 Gm. coarsely powdered Siam benzoin and then strain. In warm climates 5 per cent. of white wax may be added. For details see U.S.P., p. 31.

Remarks.—It will be seen that this official is made by digesting ground benzoin in melted lard, and *not* by mixing lard with tincture of benzoin, as the writer has known some careless druggists to do. Lard rapidly turns rancid, and the benzoin is added to hinder the decomposition.

SEVUM PRÆPARATUM—Prepared Suet

(Sev. Præp.—Mutton Suet)

The internal fat of the abdomen of the sheep (*Ovis aries* Linné, Fam. *Bovidæ*) purified by melting and straining. Preserve Prepared Suet in well-closed vessels impervious to fat. It must not be used after it has become rancid.

Summarized Description.

White solid fat; nearly inodorous; bland taste; becomes rancid on exposure to the air; insoluble in water and in cold alcohol; soluble in boiling alcohol and in cold ether and petroleum benzin; melts between 45° and 50°C.; congeals between 37° and 40°C. For details see U.S.P., p. 379.

For *tests for identity* and for *impurities*; free acid (modified volumetric test), see U.S.P.

Saponification Number.—193 to 200. Details in Part V.

Iodine Absorption Number.—33 to 48. Details in Part V.

Composition.—Stearin and palmitin, 70 per cent.; olein, 30 per cent.; *hercin*, a trace.

Remarks.—Suet turns rancid even more rapidly than lard. Borrell found that when melted suet was digested with elm bark the resulting "*ulmated suet*" kept quite well. The National Formulary gives a recipe for *benzoinated suet* which is similar to the pharmacopœial method of making benzoinated lard.

ADEPS LANÆ—Wool Fat

(Adeps Lan.—Anhydrous Lanolin)

The purified fat of the wool of sheep (*Ovis aries* Linné Fam. *Bovidæ*), freed from water. Preserve it in a cool place in well-closed containers which are impervious to fat.

Summarized Description.

Light-yellow tenacious, unctuous mass; only slight odor; insoluble in but miscible with about twice its weight of water; sparingly soluble in alcohol; freely soluble in ether and in chloroform; melts between 38° and 42°C. For details see U.S.P., p. 31.

For *tests for identity*, for *impurities;* water (loses not more than 0.5 per cent. on drying).

Alkalies and soaps (not more than 0.1 per cent. of ash and this not alkaline litmus).

Free alkalies and free acids (tested with potassium hydroxide and phenolphthalein)

Chlorides (silver nitrate test).

Glycerin (no sweet residue on evaporation of an aqueous extract).

Soluble oxidizable matter (tested with permanganate).

Petrolatum (completely soluble in boiling dehydrated alcohol), see U.S.P

Iodine absorption number.—18 to 28. Details in Part V.

Manufacture.—Crude suint (the alkaline washings from sheep-wool) is treated with acid, thereby liberating the fatty acid combination of cholesterin and isocholesterin, and also 30 per cent. free fatty acid. The fatty mixture is then treated with caustic alkali, which saponifies the free fats and emulsifies the cholesterin compounds. The mixture is centrifuged, when the cholesterin compounds separate as cream and are thus removed from bad-smelling fatty acids.

Composition.—A mixture of the esters of oleic, stearic, palmitic, cerotic, caproic, butyric, and isovaleric acids with the cholesterins and some ceryl alcohol. It contains no glyceryl compounds as do most fats. Lewkowitsch points out that this substance is more like a wax than a fat. In fact, he calls it *wool-wax.*

Remarks.—The fat of sheep-wool has already been considered as *suint,* under the head of the Potassium Salts (p. 407).

Purified suint was introduced in modern medicine under the copyrighted name *lanolin,* and since its introduction has enjoyed great popularity, because of the fact that it is more readily absorbed by the pores of the skin than lard or other fats.

It readily absorbs water, and when combined with 30 per cent. of that fluid, it forms the official *hydrous wool-fat.*

ADEPS LANÆ HYDROSUS—Hydrosus Wool Fat

(Adeps Lan. Hyd.—Lanolin)

The purified fat of the wool of sheep (*Ovis aries* Linné Fam. *Bovidæ*), containing not less than 25 nor more than 30 per cent. of water. Preserve it in a cool place in well-closed containers which are impervious to fat.

Summarized Description.

Yellowish-white, or nearly white, ointment-like mass; insoluble in but miscible with water; gives turbid solutions with ether and chloroform; loses 25 to 30 per cent. of water on evaporation on a water-bath. For details, see U.S.P., p. 32.

For *tests for identity* and for *impurities* see Wool Fat.

Manufacture.—Made by melting wool-fat, gradually adding 30 per cent. warm water, and triturating until cool.

Medical Properties.—Emollient and ointment base. Used in the following official ointments: *Belladonna, ammoniated mercury, yellow mercuric oxide* and *stramonium.*

Eucerin is an ointment base obtained from wool fat, possessing a much greater water absorbing capacity than has lanolin; it being capable of taking up seven to eight times its own weight of water. After the saponifiable fatty acids are removed from the crude suint as described under wool fat, from the cholesterin mixture by selective extraction can be separated a body consisting of a mixture (or soft fat) consisting of the esters of isocholesterin and oxycholesterin with oleic, myristinic and carnaubic acids. To this soft fat, petrolatum hydrocarbons are added as diluents and the product is marketed under the trade-marked name, eucerin.

DRUGS CONTAINING FIXED OILS

Fixed oils are usually found in the seed of plants, although there are some exceptions. Thus butternut bark (juglans, U.S.P. 1890) contains appreciable quantities of fixed oil. In many official seeds, such as strophanthus (p. 644), the fixed oil is of importance only because its presence is a source of annoyance in making pharmaceutic preparations; hence in this chapter we will discuss only those drugs that owe their entire therapeutic value to the fixed oil they contain.

The **mustards** (white or black) will be considered under the sulphocyanates (p. 675), since their activity is due to their sulphurated volatile oils.

Bitter almond will be considered under *benzaldehyde*, since its active principle, the volatile oil, is composed chiefly of that body.

AMYGDALA DULCIS—Sweet Almond

(Amygd. Dulc.)

The ripe seeds of *Prunus Amygdalus dulcis* De Candolle (Fam. *Rosaceæ*). Preserve Sweet Almond in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride from time to time to prevent attack by insects.

Constituents.—Fixed oil, 54 per cent. (expressed oil of almond, U.S.P.); albumin, 24 per cent.; the ferment emulsion; asparagin. No amygdalin.

Remarks.—Since sweet almond contains no amygdalin, no volatile oil nor hydrocyanic acid odor is produced on moistening the seed, even though the ferment, emulsin, is present. Almonds are *blanched* by removing the scurfy seed-coat. This is accomplished by immersing them in hot water for a few minutes, when the coat can be easily slipped off.

Medical Properties.—Demulcent. Used in *emulsion of almond,* U.S.P. (p. 262).

LINUM—Linseed

(Flaxseed)

The ripe seeds of *Linum usitatissimum* Linné (Fam. *Linaceæ*), without the presence or admixture of more than 3 per cent. of other fruits and seeds and foreign matter. Preserve it in tightly closed containers and add a few drops of carbon tetrachloride or chloroform from time to time to prevent attack by insects.

Summarized Description.

The meal must be free from rancid odor; a 2 per cent. decoction of a fat-free sample must not give more than a faint blue color with iodine; must yield at least 30 per cent. of oil on extraction with petroleum ether; must yield not more than 6 per cent. of ash. For details, see U.S.P., p. 236.

Constituents.—Fixed oil, 30 per cent. (oleum lini, U.S.P.); mucilage, 6 per cent. ($C_6H_{10}O_5$ and $C_5H_8O_4$); albumin; linamarin (like amygdalin), etc.

Remarks.—It is difficult to decide whether flaxseed should be grouped among the mucilaginous or the oleaginous drugs.

The whole seed is used entirely, because of the mucilage, while in the ground seed both the oil and the mucilage play a therapeutic rôle. The mucilage of the seed is interesting, as being found entirely in the outer layer of cells of the testa; hence by immersing the whole seed in water all the mucilage is extracted.

Much of the ground flaxseed of commerce is the seed deprived of part or all of its oil; hence the pharmacopœial test given above requiring at least 30 per cent. of oil.

Linseed contains some starch, but not large amounts, and thus differs from most of the adulterants of the ground seed. This explains the pharmacopœial test for "limit of starch," the test having been devised by Professor J. U. Lloyd.

Medical Properties.—The mucilage (hence the unground seed) is demulcent. Therefore an infusion of the whole seed is used as a basis of domestic cough-mixtures, while a thicker solution is sometimes used as a bandolin or as a face jelly, although for this purpose quince seed or tragacanth is more useful. Ground seed mixed with hot water to thick paste forms the familiar "*flaxseed poultice.*"

PEPO—Pepo

(Pumpkin Seed)

The dried ripe seeds of cultivated varieties of *Cucurbita Pepo* Linné (Fam. *Cucurbitaceæ*), without the presence or admixture of more than 5 per cent. of other substances.

Constituents.—Fixed oil, 20 to 40 per cent., sugar, starch and resin. The oil consists of linolein, olein, palmitin and stearin; while the resin is a combination of a phytosterol ($C_{27}H_{46}O$) with hydroxycerotic acid.

Medical Properties. Popularly considered as a tenifuge, but Power and Salway after an exhaustive examination of the drug report their inability to find any ingredient that would be likely to expel tapeworm.

Dose;—30 grammes (1 ounce).

LYCOPODIUM—Lycopodium

(Lycopod.)

The spores of *Lycopodium clavatum* Linné (Fam. *Lycopodiaceæ*), without the presence or admixture of more than 2 per cent. of impurities.

Constituents.—Fixed oil, 43 per cent. consisting of lycopod-oleic, dioxy-stearic, palmitic and myristic acids.

Remarks.—The official definition of lycopodium is "the spores of *Lycopodium clavatum*," etc. The spores of non-flowering plants are organs midway between the fruit and the seed of flowering species, though there is a decided difference in the way the two sprout into new plants.

The large quantity of oil contained in lycopodium accounts for its mobility—its smooth, slippery character—as well as causing the remarkably quick combustion of lycopodium when blown into a flame. It is very difficult to extract the oil from lycopodium, as it is next to impossible completely to break the walls of the individual cell which forms each sporule. By long contusion with sand the result may be reached.

Because of its mobility it is called "*witch-powder*" in some sections of the country.

Medical Properties.—Externally, as a dusting-powder. Its use as a dusting-powder for pills has been already given.

Soy beans, the seeds of *Glycine hispida*, the chief foodstuff of the Manchurians, have lately become an important article of commerce because of the oil that can be expressed from them. This oil is excellent for soap making and can also be used as a salad oil.

SOAPS

Soaps are products resulting from the action of sodium and potassium hydroxide on oils or fats. All the ingredients employed in commercial soap-making are more or less impure, hence the products are not definite chemical compounds.

The pharmacopœia recognizes as soap—*sapo*—made from olive oil and soda—and *sapo mollis*—from linseed oil and potassa. Fixed oil are combinations of the oleate, stearate, and palmitate of glyceryl. If we take glyceryl oleate and treat it with sodium hydroxide we get a reaction quite similar to that occurring when fat is treated with steam (p. 610), namely:

$$\underset{\substack{\text{Olein}\\ \text{(Glyceryl oleate.)}}}{C_3H_5(C_{18}H_{33}O_2)_3} + \underset{\substack{\text{Sodium}\\ \text{hydroxide}}}{3NaOH} = \underbrace{\underset{\text{Glycerin}}{C_3H_5(OH)_3} + \underset{\text{Sodium oleate.}}{3NaC_{11}H_{33}O_2}}_{\text{Soap.}}$$

SAPO—Soap

(White Castile Soap)

Soap prepared from olive oil and sodium hydroxide. Preserve dried or powdered soap in well-closed containers.

Summarized Description.

White or nearly white solid, in bars or a yellowish-white powder; faint peculiar odor, free from rancidity; disagreeable alkaline taste; soluble in alcohol and water; alkaline to litmus. For details see U.S.P., p. 366.

For *tests for identity*, for *impurities*; water (loss on evaporation, not more than 36 per cent.).

Soap from animal fats (hot alcoholic solution, about 1 to 35, does not gelatinize on cooling).

Metallic impurities. (Modified hydrogen sulphide test.)

Sodium chloride, sodium carbonate or silica (hot alcohol solution dissolves at least 99 per cent.).

Silica (the residue left in above test after washing with water should leave not more than 0.15 per cent.

Sodium hydroxide (alcoholic solution not reddened with phenolphthalein, see U.S.P.

Iodine Absorption Number.—(Of the separated acids) 84 to 90. Details in Part V.

Remarks.—Soap is a product of the treatment of an oil, supposedly olive oil, with sodium hydroxide. Now much commercial soap is made by direct treatment of fatty acids with sodium bicarbonate. This is called "Castile soap," because originally made in the city of Castile, Spain, and at the present time the finest brand of Castile soap on the market is the "Yaritu" brand manufactured in that city. The large majority of the so-called Castile soap, however, is manufactured in Marseilles.

Soap is a hard, whitish solid, insoluble in salt water, very soluble in alcohol, and somewhat soluble in cold water. When a solution of soap is made with excess of water, the soap breaks into free alkali and fatty acids. The alkali immediately attacks the skin if brought in contact with it, but before it can do much harm the fatty acid acts as a soothing agent. This explains the whole plan of washing with soap, the alkali removing grease and at the same time removing minute traces of skin, while the fatty acids prevent the burning which invariably results if the free alkali were used for the same purpose.

As seen above, Castile soap is a mixture of glycerin and sodium oleate. The red Castile soap is colored by the addition of ferrous oxide, which is black, and this, on exposure to air, is oxidized to red ferric oxide—iron rust. The effect can be noticed by making a fresh cut through a cake of mottled Castile soap, which shows on the interior black streakings which, on exposure to air, gradually assume the red hue of the rest of the soap. The coloring (or mottling) is simply to please the eye, as the ferric oxide is of no influence, save to increase weight.

Soap is used chiefly externally, although it is sometimes administered internally as a laxative, especially in purgative pills. For this purpose it is used in the official pills of *aloes* and of *asafetida.* It is also a constituent of *compound extract of colocynth,* and thus is the excipient in *compound cathartic pills* (p. 312).

An alcoholic solution of soap containing camphor and oil of rosemary is official as "soap liniment" (p. 266).

SAPO MOLLIS—Soft Soap

Sapo Moll.

Condensed Recipe.

Dissolve 86 Gm. potassium hydroxide in 100 mils of water, warm, add 430 Gm. cottonseed oil, stir, saponify by heat, clear with alcohol, using more potassium hydroxide, if necessary. For details see U.S.P., p. 367.

Summarized Description.

Soft unctuous yellowish-white to brownish-yellow mass; slight characteristic odor; alkaline taste; solution is alkaline to litmus and to phenolphthalein; 97 per cent. should be soluble in hot alcohol; should contain from 0.1 to 0.25 per cent. of free potassium hydroxide, and not more than 52 per cent. of water. For details see U.S.P., p. 367.

Soft soap is a soap made by treatment of linseed oil with potassa, and clearing the product with an appropriate quantity of alcohol. *Green soap* is a soft soap made with potassa and greenish rape seed oil.

The two soaps (hard and soft) are interesting as illustrating the different actions of the salts of two metals. The sodium salts are usually efflorescent and, similarly, Castile soap is found to effloresce on standing. The potassium compounds, like potassa soap, are deliquescent.

Soft soap is used externally in skin troubles, and is a constituent of the official *liniment of soft soap* (p. 266).

The liquid soaps now so popular for toilet surgical and shampoo use are prepared by saponifying cottonseed oil or coconut oil or mixtures of the two with potassium hydroxide.

While Castile soap and soft soap are the only official soaps, in the limited sense of the term, we have other official products, that are usually considered as soaps, although it is a question whether all of them are properly so grouped.

LINIMENTUM AMMONIÆ—Ammonia Liniment

(Lin. Ammon.—Volatile Liniment—Hartshorn Liniment)

Condensed Recipe.

Shake 250 mils of ammonia water with 750 mils of sesame oil. For details see U.S.P., p. 232.

Remarks.—Whether this is a real soap or merely an emulsion of sesame oil in a small amount of ammonia soap can be figured out by molecular proportions, assuming as the reaction the following equation.

$$\underset{884}{\overset{\text{Olein}}{C_3H_5(C_{18}H_{33}O_2)_3}} + \underset{51}{\overset{\text{Ammonia water}}{3NH_3}} + 3H_2O = C_3H_5(OH)_3 + \overset{\text{Ammonia liniment}}{3NH_4C_{18}H_{33}O_2}$$

This equation shows that every 884 grammes of oil will require 51 grammes of absolute ammonia (or 510 grammes of 10 per cent. ammonia water) for complete saponification. Comparison of these figures with the pharmacopœial quantities will show that the amount of ammonia water there prescribed falls far short of this proportion.

Hartshorn liniment, as this preparation is popularly called, is a valuable and largely used embrocation.

LINIMENTUM CALCIS—Lime Liniment

(Lin. Calc.—Carron Oil)

Condensed Recipe.
Mix together 500 mils of lime water and 500 mils of linseed oil.

Remarks.—There is no question that this liniment is merely an emulsion of linseed oil in small amount of calcium-linseed oil soap. Calculations similar to those given under ammonia liniment, will show that the amount of calcium hydroxide is far short of the quantity required for complete saponification.

The value of this liniment, popularly called *Carron oil*, in burns, has been mentioned on p. 470.

EMPLASTRUM PLUMBI—Lead Plaster

This preparation, the manufacture of which is described at length in Part VII as well as on p. 549, is mentioned at this place as an example of a true soap, of that type which is insoluble in water. It is a lead oleopalmitate, even as soap U.S.P. is a sodium oleopalmitate.

The official *oleates* are scarcely to be considered as soaps, as they all contain a large excess of oleic acid.

In most works on pharmacy the chapter on fats and soaps is considered the proper place to consider the petroleum products, but these have already been described on p. 576, for reasons mentioned there; hence at this place all that is necessary is the mention that animal and vegetable fats being the oleates, stearates, and palmitates of glyceryl, or closely allied bodies, when treated with sodium or potassium hydroxide, split into glycerin and soap; in other words, can be saponified. The mineral fats—petrolatum and similar products—do not saponify when treated with sodium or potassium hydroxide. Again, animal and vegetable fats, on standing, become oxidized, partially splitting into glycerin and the fatty acids, becoming rancid, as we say.

Petroleum fats do not turn rancid, do not oxidize, hence ointments made with vaseline and similar petroleum fats keep indefinitely. Petroleum, however, is not absorbed by the skin as readily as are the animal and vegetable fats.

WAXES

Among the derivatives of the fatty hydrocarbons higher than $C_{18}H_{38}$ some bodies of pharmaceutic interest are found. $C_{27}H_{56}$ yields ceryl alcohol or *cerotin* ($C_{27}H_{55}OH$), while the body, $C_{30}H_{61}OH$ or $C_{31}H_{63}OH$, is known as melissyl alcohol (sometimes called *myricyl alcohol*).

The ultimate analysis of these bodies containing a large number of carbon atoms does not enable us accurately to determine the formula. The difference in the percentage of carbon and hydrogen in the bodies

$C_{30}H_{61}OH$ and $C_{31}H_{63}OH$ varies so slightly as to give rise to doubt as to which is the exact formula.

Thus, $C_{30}H_{61}OH$ has the molecular weight:

$C_{30} = 30 \times 12 = 360$
$H_{62} = 62 \times 1 = 62$
$O = 1 \times 16 = 16$

molecular weight, 438, and contains

Carbon, $\frac{360}{438} \times 100 = 82.19$ per cent.
Hydrogen, $\frac{62}{438} \times 100 = 14.15$ per cent.
Oxygen, $\frac{16}{438} \times 100 = 3.65$ per cent.
99.99 per cent.

While $C_{31}H_{63}OH$ has the molecular weight:

$C_{31} = 31 \times 12 = 372$
$H_{64} = 64 \times 1 = 64$
$O = 1 \times 16 = 16$

molecular weight, 452, and contains

Carbon, $\frac{372}{452} \times 100 = 82.30$ per cent.
Hydrogen, $\frac{64}{452} \times 100 = 14.15$ per cent.
Oxygen, $\frac{16}{452} \times 100 = 3.54$ per cent.
99.99 per cent.

The difference in percentage of carbon in these substances (82.19 per cent. and 82.30 per cent.) is no greater than the permissible limit of error in analysis; while the percentage of hydrogen in the two is identical.

The oxidation of ceryl alcohol yields *cerotinic acid*, $C_{26}H_{53}COOH$, while the oxidation of melissyl alcohol gives *melissic acid*, $C_{29}H_{59}COOH$ or $C_{30}H_{61}COOH$.

These four bodies are of interest as constituents of the various waxes, they being esters of the two alcohols, with the two acids just mentioned and other fatty acids.

CERA FLAVA—Yellow Wax

(Cer. Flav.—Beeswax)

A product obtained by melting and purifying the honey-comb of the bee, *Apis mellifera*, Linné (Fam. *Apidæ*).

Summarized Description.

Yellow to gray-brown solid; agreeable honey-like odor; faint characteristic taste; brittle in the cold; plastic at heat of the hand; insoluble in water; sparingly soluble in cold alcohol; partly soluble in hot alcohol; completely soluble in chloroform, ether and in fixed and volatile oils; sp. gr. 0.950 to 0.960. For details see U.S.P., p. 104.

For *tests for identity*, for *impurities*; fats, fatty acids, Japan wax or rosin (boil with solution of sodium hydroxide 1 in 7 and filter through asbestos; filtrate treated with hydrochloric acid gives no precipitate).

Soap (boil with water and filter; filtrate treated with hydrochloric acid gives no precipitate), see U.S.P.

Ester Number.—72 to 77. Details in Part V.

Composition.—The official beeswax consists chiefly of melissyl palmitate, $C_{30}H_{61}C_{16}H_{31}O_2$, melissyl melissate, $C_{30}H_{61}C_{30}H_{59}O_2$, and free cerotinic acid.

Yellow wax is defined as a concrete substance prepared by *Apis mellifera*, and is a well-known commercial product, consisting of the comb the bee prepared in which to store its honey, and is supposed to be an excretion of the animal itself.

In obtaining wax the comb is taken, drained of its honey, washed in cold water, and then melted and strained, the product being the bright yellow solid, of pleasant, aromatic odor, having specific gravity, 0.950 to 0.960, melting at 63° to 64°C.

The large demand for wax has led to many adulterations of same, the favorite sophistication being rosin or paraffin. For detecting these, neither the specific gravity nor the melting-point is a criterion of quality, for although paraffin has a lower specific gravity than that of wax, and rosin a higher specific gravity, a combination of the two can be made to possess the same specific gravity as pure wax; hence chemical tests of the pharmacopœia are essential for intelligent examination. The test for rosin is that when a sample is boiled with 15 per cent. solution of potassa and filtered, such filtrate should give no precipitation on addition of acid.

In other words, wax itself is unaffected by 15 per cent. potassium hydroxide, whereas the rosin dissolves, forming potassium abietinate. Therefore, if rosin is present, the filtrate contains this potassium abietinate, and the solution when treated with acid precipitates the free abietinic acid.

If the alkaline solution is filtered through paper it will dissolve some of the paper pulp, which will be precipitated on addition of acid, leading to wrong conclusions; hence the present pharmacopœia directs filtration through asbestos.

A useful test for paraffin is based on the fact that wax is decomposed by boiling with sulphuric acid, while paraffin remains unchanged, as explained under paraffin. This test is not given in the monograph of the present pharmacopœia; the absence of paraffin being determined by the ester number. Pure wax has an ester number of from 72 to 77, while paraffin is zero, and admixtures run somewhere between 0 and 72.

CERA ALBA—White Wax

(Cer. Alb.)

Yellow Wax, bleached

Summarized Description.

Yellowish-white somewhat translucent solid; faint characteristic odor; nearly tasteless; free from rancidity; sp. gr. 0.950 to 0.960; melts between 62° and 65°C. For details see U.S.P., p. 104.

Ester Number.—72 to 79. See Part V.

Acid Value.—17 to 23. See Part V.

Remarks.—White wax represents the yellow variety which has been bleached by exposing to sunlight in thin layers. Chemical methods of bleached are sometimes employed, but the product is not as good as is the sun-bleached. Much of the white wax of commerce is adulterated with paraffin.

CETACEUM—Spermaceti

(Cetac.)

A concrete, fatty substance, obtained from the head of the sperm whale, *Physeter macrocephalus* Linné (Fam. *Physeteridæ*).

Summarized Description.

White, somewhat translucent, slightly unctuous masses; scaly crystalline fracture; pearly luster; bland mild taste; insoluble in water; almost insoluble in cold alcohol; soluble in boiling alcohol, ether, chloroform, carbon disulphide, fixed and volatile oils; sp. gr. 0.938 to 0.944; melts between 42° and 50°C. For details see U.S.P., p. 107.

For *tests for identity,* for *impurities:* paraffin (dissolves in boiling alcohol).

Stearic acid (melt, shake with ammonia water and filter; filtrate not more than turbid on acidulation), see U.S.P.

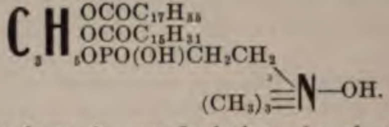
Remarks.—Spermaceti is obtained from the whale by removing from the recently killed animal the oily liquid contained in a cavity in the head. This oil soon congeals when it is submitted to strong pressure. After the liquid part has been expressed, the press cake, crude spermaceti, is purified by melting in water, then boiling with weak alkali, and then washing with water.

Spermaceti consists chiefly of cetyl palmitate, $C_{16}H_{33}C_{16}H_{31}O_2$ (p. 651), and is a white, somewhat translucent solid, breaking with a scaly fracture, having a specific gravity of 0.938 to 0.944, melting at between 42 and 50°C. It is a constituent of cold cream, and its chief use is for hardening ointments.

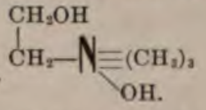
Chinese wax is chiefly ceryl cerotate, $C_{27}H_{55}C_{27}H_{53}O_2$, and is the secretion from an insect living on the tree *Ligustrum lucidum*. It is frequently confounded with *Japanese wax*, which is of vegetable origin, being found in the fruit of *Rhus succedanea*.

LECITHIN AND CHOLESTERIN

These two substances can best be discussed at this place, since they are allies of fats. *Lecithin* is a complex ester of glycerin having the graphic formula



On analyzing this formula, we find that the glyceryl group is combined with a stearic acid group, a palmitic acid group, and a phosphoric acid group; while to the latter is attached a choline group,



Barbieri and others claim that it is not a definite chemical but a mixture of olein, stearin, a substance containing nitrogen, sulphur and phosphorus, called ovine, and cholesterol.

Cholesterol is an alcohol having the formula $C_{27}H_{45}OH$, and, as mentioned on p. 662 is the alcohol constituent of the ester, wool-fat. Lecithin, choline, and cholesterin are found in animal tissue, such as the brain, yolk of egg, and oxgall (p. 835).

Phytosterols are alcohols found in plants, that are similar in composition to cholesterol. A number of these have been isolated and some are of importance by way of identifying the material in which they are found, since they can be separated in characteristic crystals. It now seems that many of the plant resins are combinations of phytosterols with the higher acids.

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CHAPTER XLII

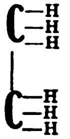
ORGANIC PRODUCTS OF INTERMEDIATE CHARACTER

Among the organic chemicals used in pharmacy are several which can scarcely be grouped either as derivatives of hydrocarbons of the fatty series or of the aromatic series. Among these bodies are classed the cyanogen bodies, carbonic acid derivatives, and a few ringed bodies of character midway between the aliphatic compounds already described and the aromatic bodies.

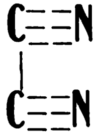
CYANOGEN BODIES

The cyanides can be considered as ethyl or methyl derivatives in which some of the hydrogen is replaced by nitrogen, as can best be shown by comparison of the formulas of ethane and cyanogen.

Ethane.



Cyanogen.

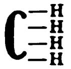


Cyanogen, $(CN)_2$, was discovered by Gay Lussac in 1815, and is made by heating silver cyanide. It is a gaseous body of such poisonous characteristics as to render its manufacture and use unsafe.

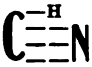
A derivative of same, however, paracyanogen, $(C_2N_2)_3$, is of interest in pharmacy, as the black precipitate which forms in hydrocyanic acid solution on standing.

Hydrocyanic Acid (HCN).—This substance was isolated by Scheele in 1782 from oil of bitter almond, and can be considered as methane, in which three of the hydrogen atoms are replaced by one of nitrogen, as shown by comparison of formulas given below:

Methane.



Hydrocyanic acid.



As mentioned above, it is one of the products found in volatile oil of almond, and a description of the process whereby it is extracted will be left until this official is reached. (See p. 704.)

It is prepared by either of the processes given under diluted hydrocyanic acid, or by treating chloroform with ammonia gas under pressure, viz.,

$$CHCl_3 + NH_3 = HCN + 3HCl.$$

Pure hydrocyanic acid is a very poisonous gas, soluble in water, and used in medicine only in dilute form.

ACIDUM HYDROCYANICUM DILUTUM—Diluted Hydrocyanic Acid (Acid. Hydrocyan. Dil.—Acidum hydrocyanicum dilutum P. I.)

An aqueous solution containing not less than 1.9 per cent. nor more than 2.1 per cent. of HCN (27.02) and not more than 0.1 per cent. of HCl. Preserve it in small, dark ambered-colored, well-stoppered vials.

Summarized Description.

Colorless liquid; bitter almond odor; very poisonous; acid to litmus. For details see U.S.P., p. 15.

For *tests for identity*, for *impurities:* Hydrogen chloride (modified volumetric test) and for *assay*, see U.S.P., p. 15, and also Part V of this book.

Diluted hydrocyanic acid is an aqueous solution containing about 2 per cent. of hydrocyanic acid gas. It is prepared by distilling a mixture of potassium ferrocyanide with sulphuric acid and water, in a retort, and diluting distillate until it is 2 per cent. strength.

For a simple extemporaneous method of preparing the diluted acid, however, the last pharmacopœia directed the treating of silver cyanide with hydrochloric acid and a sufficient quantity of distilled water, the advantage of this process being that it does not require distilling, the silver cyanide combining with the hydrochloric acid and forming insoluble silver chloride, while the hydrocyanic acid goes into solution.

Dilute hydrocyanic acid is a colorless liquid, which is not very stable, and should be dispensed only when comparatively fresh; hence it is highly advantageous to follow the pharmacopœial alternative process, and manufacture same from silver cyanide.

It possesses a pungent odor (characteristic of bitter almond oil or peach kernel), and should be both smelled and tasted with utmost caution, even in the dilute form. It is used as a sedative and expectorant.

Dose.—0.1 mil (1½ minims).

Mention should be made of the fact that formerly *Scheele's hydrocyanic acid* was a popular form for administering this chemical. It contained 5 per cent. absolute hydrocyanic acid, and the confusion arising from the use of these two strengths of the acid (5 per cent. and 2 per cent.) was positively dangerous. At present, however, Scheele's acid is very rarely employed.

Hydrocyanic acid forms salts with metals, such products being called cyanides. But one cyanide—that of sodium—is official and this is considered among the sodium compounds.

Hydrocyanic acid also forms ester-like compounds with organic radicles. As an example might be cited methyl cyanide, CH_3CN. The term cyanide, however, is not applied to these bodies, they being called *nitriles*, and in these bodies the radicle is directly attached to the carbon atom and not to the nitrogen. In this way they differ from the *isonitriles*, which are isomeric bodies in which the radicle is attached to the nitrogen instead of the carbon. The difference between these bodies is best shown by the appended graphic formulas:

Methyl nitrile.

$$CH_3-C\equiv N$$

Methyl isonitrile.

$$CH_3-N\equiv C$$

Isonitriles are of interest only as being exceedingly poisonous gases of disgusting odor, such as phenyl isonitrile, which is formed in a test for chloroform. (See p. 581.)

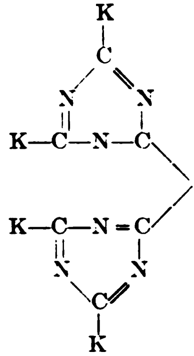
Cyanogen forms compounds with iron, forming ferrocyanides and ferricyanides, according to the valence of the metal. One of these (potassium ferrocyanide) is official, while potassium ferricyanide is recognized by the pharmacopœia as a test solution. The former of these bodies has been discussed among the potassium compounds, but this is the proper place for chemical comparison of these two interesting substances.

Potassium ferrocyanide, $K_4Fe(CN)_6$, may be considered, for the sake of remembering the formula, as a combination of one molecule of ferrous cyanide, $Fe(CN)_2$, with four molecules of potassium cyanide; that is, $Fe(CN)_2 + 4KCN$.

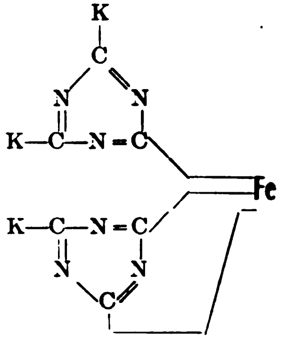
Potassium ferricyanide can be considered, on the other hand, as a combination of ferric cyanide with three molecules of potassium cyanide, that is, $Fe(CN)_3 + 3KCN$.

As in the case of the dissection of the alum formula (p. 492), this must not be considered as meaning that these two bodies, the ferrocyanide and the ferricyanide, are mere mechanical combinations of cyanides of potassium and iron, for in both cases there is an intimate combination between the cyanogen group, the iron, and the potassium, as is best shown in the appended graphic formulas:

Potassium ferrocyanide



Potassium ferricyanide



As already mentioned on p. 501, the chief pharmaceutic value of these two bodies is as tests for the iron compounds, the ferrocyanide giving blue precipitate with ferric salts and the ferricyanide giving blue only with ferrous salts.

Cyanic Acid (HCNO).—This differs from hydrocyanic acid in containing one atom of oxygen. It in itself possesses no pharmaceutic interest. Its ammonia salt, however, ammonium cyanate, NH_4CNO, is of interest as the product from which urea was first made synthetically (p. 677).

Thiocyanic acid, or *sulphocyanic acid*, HCNS, yields the potassium thiocyanate, KSCN, which is recognized in the pharmacopœia in the form of a test solution, it being the most delicate test for iron, a drop of the solution giving a clear red tint to a liquid containing the merest trace of a ferric salt.

Mercuric thiocyanate, $Hg(CNS)_2$, is the chief constituent of the dangerous fireworks, "Pharaoh's serpents," these being a mixture of mercury salt with starch or other excipient, and when ignited it swells to enormous proportions, forming shapes somewhat similar to serpents. One of the products of the burning, however, is hydrocyanic acid, and their use by children should be prohibited.

As the organic cyanides possess isomeres which were called isonitriles, so thiocyanic acid possesses an isomere, isothiocyanic acid, the two differing in exactly the same way as the two nitriles, as shown in graphic formulas given below:

Thiocyanic acid.	Isothiocyanic acid.
$H-C\equiv N=S$	$H-N=C=S$

The allyl ester of isothiocyanic acid, C_3H_5NCS, is interesting as the chief constituent of oil of mustard.

OLEUM SINAPIS VOLATILE—Volatile Oil of Mustard

(Ol. Sinap. Vol.—Mustard Oil)

A volatile oil produced synthetically or obtained from the seed of *Brassica nigra* (Linné) Koch (Fam. *Cruciferæ*) (freed from fatty oil) by maceration with water and subsequent distillation. It yields not less than 92 per cent. of allyl iso-thiocyanate [C_3H_5SCN = 99.12]. The label must indicate whether the Oil has been made synthetically or obtained from black mustard. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, pale-yellow, strongly refractive liquid; very pungent odor; terribly irritating; sp. gr. 1.013 to 1.020; optically inactive; distils between 148° and 154°C. For details see U.S.P., p. 302.

For *tests for identity*, for *impurities*. Alcohol, chloroform, petroleum or fatty oils (entire distillate has the same specific gravity).

Phenols (alcoholic solution not turned blue with ferric chloride) and for *assay*, see U.S.P., p. 302 and also Part V of this book.

Composition.—Chiefly allyl-isothiocyanate, $CH_2 = CH - CH_2NCS$, and some propenyl-isothiocyanate, $CH_3CH = CHNCS$.

Remarks.—The manufacture of this volatile oil given in the above official definition will be explained below, when considering constituents of *black mustard.* Oil of mustard is one of the most violently irritating of volatile oils, even pouring of the oil from one bottle to another producing serious irritation to the mucous membrane of the eye and nose, hence the pharmacopœial caution as to smelling.

The assay, based as it is on the behavior of volumetric solution of silver nitrate, will be explained along with that testing liquid (p. 903).

Medical Properties.—A powerful irritant, used almost exclusively externally as a rubefacient.

Dose.—0.008 mil (⅛ minim).

SINAPIS NIGRA—Black Mustard

(Sinap. Nig.—Brown Mustard)

The ripe seeds of *Brassica nigra* (Linné) Koch (Fam. *Cruciferæ*), without the presence or admixture of more than 5 per cent. of other seeds or other foreign matter. Preserve powdered Black Mustard in tightly closed containers.

Constituents.—Fixed oil, 25 per cent., the glucoside, *sinigrin*, or *potassium myronate;* the ferment, *myrosin;* mucilage, proteids, etc.

Remarks.—Under glucosides (p. 640) the equation showing the hydrolysis of the glucoside, potassium myronate, into glucose, potassium bisulphate, and allyl-isothiocyanate is given. Here let it be added that the latter substance constitutes the bulk of the volatile oil of mustard. This oil is not found in the dry seed, but is produced when the dry powder is moistened with water by the reaction between the glucoside, potassium myronate, and the ferment, myrosin, both substances occurring in the seed; that black mustard yields its fixed oil on expression, that after the fixed oil is pressed out, the dry squeezed mass, on moistening with water, yields volatile oil by the induced action of ferment on glucoside; and, finally, that the official volatile oil of mustard is obtained by distillation of the moist pulp.

In preparing "mustard leaves," as they are usually called, see mustard plaster (p. 343), the ground mustard is first percolated with benzin. This solvent extracts the fixed oil, which, if allowed to remain, would grease the paper on which the mustard is spread. Mustard plasters can be prepared extemporaneously by mixing powdered mustard with water and spreading on a cloth. The water used in moistening this or the ready-made mustard leaves must be cold, not hot, as hot water destroys the activity of the ferment, myrosin, preventing the formation of volatile oil.

Medical Properties.—Condiment, emetic, rubefacient. Official preparation, *mustard plaster* (p. 343).

Dose.—As an emetic, 10 grammes (2½ drachms).

SINAPIS ALBA—White Mustard

(Sinap. Alb.—Yellow Mustard)

The ripe seeds of *Sinapis alba* Linné (Fam. *Cruciferæ*), without the presence or admixture of more than 5 per cent. of other seeds or other foreign matter. Preserve powdered White Mustard in tightly closed containers.

Constituents.—Fixed oil, 25 per cent. The glucoside, *sinalbin*, $C_{30}H_{44}N_2S_2O_{16}$, which hydrolyzes under influence of the ferment myrosin into dextrose, *acrinyl sulphocyanate*, and *sinapin bisulphate* (the last two giving white mustard its activity), proteids, mucilage, *sinapin sulphocyanide*, etc.

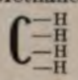
Remarks.—It will be seen from the above that the activity of white mustard, like that of black mustard, depends on a sulphurated volatile oil, and likewise is produced by the hydrolysis of a glucoside. It is important to note, however, that neither the glucoside nor the volatile oil has the same composition as those found in black mustard.

The powdered English mustard used as a condiment possesses a bright yellow tint, while the official mustards, when powdered, are from gray to green-brown. The bright hue of the English article is due to admixture with turmeric, an addition that can scarcely be considered in this case as an adulteration.

Medical Properties and Dose.—Same as black mustard.

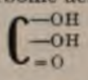
Carbonic Acid Derivatives.—As hydrocyanic acid is considered as a methane in which three of the hydrogens are replaced by one nitrogen atom, so can carbonic acid be considered as methane, in which two of the hydrogens are replaced by two hydroxyls and two by one atom of oxygen, while formic acid can be considered as methane in which one of the hydrogen atoms is replaced by hydroxyl, and two by one atom of oxygen, as can best be shown by the graphic formulas given below:

Methane.



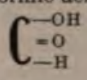
$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{H}\\-\mathrm{H}\\-\mathrm{H}\\-\mathrm{H}\end{array}\right.$$

Carbonic acid.



$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{OH}\\-\mathrm{OH}\\=\mathrm{O}\end{array}\right.$$

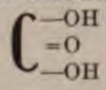
Formic acid.



$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{OH}\\=\mathrm{O}\\-\mathrm{H}\end{array}\right.$$

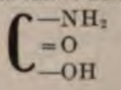
Taking the graphic formula of carbonic acid given above as a type, we find several organic bodies which can be considered as direct derivatives thereof. For example, by replacing two hydroxyl groups by chlorine we get a body, $COCl_2$, which is called *carbon oxychloride*, or more generally, *phosgene*. This body is made by oxidation of chloroform with chromic acid, and occasionally chloroform decomposes with its formation (particularly under the action of gas or lamp light), in which case the chloroform is, of course, dangerous for inhalation, as explained on p. 581. The hydroxyl groups of carbonic acid can be replaced by other bodies—for example, the amido group, NH_2. Thus, carbonic acid in which one of the hydroxyl groups is replaced by an amido group gives us carbamic acid, while if the two hydroxyl groups are replaced by two amido groups, we obtain urea. This can best be explained by examination of the graphic formulas given below:

Carbonic acid.



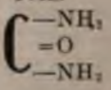
$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{OH}\\=\mathrm{O}\\-\mathrm{OH}\end{array}\right.$$

Carbamic acid.



$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{NH_2}\\=\mathrm{O}\\-\mathrm{OH}\end{array}\right.$$

Urea.



$$\mathrm{C}\left\{\begin{array}{l}-\mathrm{NH_2}\\=\mathrm{O}\\-\mathrm{NH_2}\end{array}\right.$$

Carbamic acid is of interest as being a constituent of the official ammonium carbonate, as explained on p. 453.

ÆTHYLIS CARBAMAS—Ethyl Carbamate

(Æthyl Carbam.)

The ethyl ester [$C_3H_7O_2N$ or $CO(OC_2H_5)NH_2 = 89.07$] of carbamic acid. Preserve it in well-closed containers.

Summarized Description.

Colorless, columnar crystals or scales; cooling saline taste; soluble in about 0.45 parts of water, in about 0.6 parts of alcohol, in about 3.7 parts of glycerin and also in chloroform, ether and olive oil; melts between 48° and 50°C. For details see U.S.P., p. 33.

For *tests for identity* and for *impurities:* Urea (solution not precipitated by nitric acid), see U.S.P.

Remarks.—This body, commonly called *urethane*, is the ethyl ester of carbamic acid, the formula being $CO<{NH_2 \atop OC_2H_5}$. It was discovered by Dumas in 1833, and is made by treating phosgene with alcohol and converting the resulting body, the ethyl ester of chlorocarbonic acid, $CO<{Cl \atop OC_2H_5}$, into urethane by treatment with ammonia gas.

It is also prepared by treating cyanic acid with alcohol:

$$HCNO + C_2H_5OH = CO<{NH_2 \atop OC_2H_5}.$$

It occurs in colorless crystals or scales, and is used as a hypnotic.

Dose.—1 gramme (15 grains).

Euphorin is phenyl urethane, shown by formula $CO<{NHC_6H_5 \atop OC_2H_5}$. It will be seen above that urethane is made by treatment of the ethyl ester of chlorocarbonic acid with ammonia gas:

$$CO{Cl \atop OC_2H_5} + NH_3 = CO<{NH_2 \atop OC_2H_5} + HCl.$$

If, instead of ammonia, aniline is used, euphorin results:

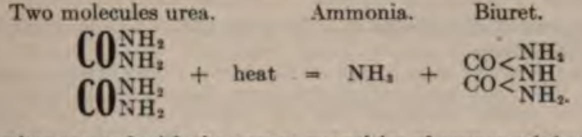
$$CO{Cl \atop OC_2H_5} + C_6H_5NH_2 = CO{NHC_6H_5 \atop OC_2H_5} + HCl.$$

Euphorin is used as an antithermic, antirheumatic, and antiseptic.

Ural is chloral urethane and is hypnotic, as is also **somnal,** ethylated ural, this being made by treating chloral with alcohol and urethane.

Urea, $CO(NH_2)_2$.—This body is a normal constituent of the urine, and was found therein in 1773 by Rouelle. Its chief interest is based on the fact that its manufacture was the first organic synthesis performed, this historic work being performed by Wöhler in 1828 by heating ammonium cyanate. It has no interest in pharmacy other than as a constituent of the urine.

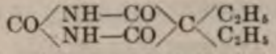
By heating urea, *biuret* is obtained by the following reaction:



$$\begin{matrix} CO{NH_2 \atop NH_2} \\ CO{NH_2 \atop NH_2} \end{matrix} + \text{heat} = NH_3 + \begin{matrix} CO<{NH_2 \atop NH} \\ CO<NH_2. \end{matrix}$$

Biuret, when treated with the proper quantities of copper sulphate and potassium, hydroxide solutions gives the characteristic violet-red color, hence the so-called biuret reaction of urea produced on heating urine with these chemicals.

Di-ethyl barbituric acid or *di-ethyl-malonyl-urea* is the largely used hypnotic *veronal*. Its graphic formula is



and it is made by interaction of the esters of di-ethyl-malonic acid with urea in the presence of metallic alcoholates. Veronal is a white crystalline powder, melting at 188°C. and soluble in 150 parts of water. It is given in insomnia in 5 to 15-grain doses.

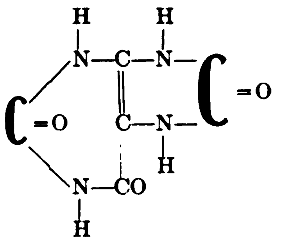
Uric acid was discovered by Scheele in 1776, and is found as a constituent of the urine and of the excrement of serpents. It is made synthetically, but the synthesis is of interest only as establishing its graphic formula, which is given below.

It is generally prepared from *guano*, the dried dung of sea-birds.

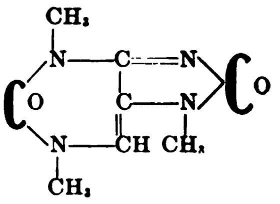
Uric acid is interesting to us because of the similarity of its formula to that of the well-known so-called alkaloids, theobromine, theophylline, and caffeine, as is shown by the comparison of the four formulas printed below.

Caffeine is uric acid in which three hydrogen atoms are replaced by three methyl (CH_3) groups, and with the central CO group changed to CH; while theobromine and theophylline contain only two methyl groups instead of three, as does caffeine.

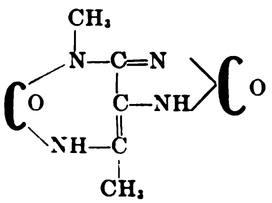
Uric acid.



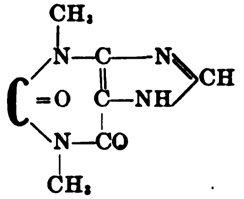
Caffeine.



Theobromine.

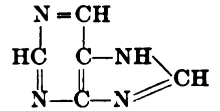


Theophylline.

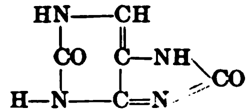


Fischer, in his classic research on these bodies, considers them not so much as allies of uric acid, but as derivatives of purine and of xanthine. His formulæ for these two bodies are:

Purine.



Xanthine.



Comparison of these two formulæ with the four given above show that their difference is only one of configuration.

Theobromine is the active constituent of *Theobroma Cacao*, and is obtained from the press cake of the cacao seed (after expressing the oil of theobroma) by mixing it with half its weight of slaked lime and boiling with 80 per cent. alcohol. The crude theobromine obtained from the alcoholic solution is purified by recrystallization.

Theobromine sublimes at 290°C. without melting, and is so sparingly soluble in water that it has to be dispensed as the more soluble alkaline combinations, such as sodium theobromine. As these alkaline bodies are more or less irritating, double salts, such as diuretin, are to be preferred.

CAFFEINA—Caffeine

(Caffein.—Theine)

A feebly basic substance [$C_8H_{10}N_4O_2 + H_2O$ or $C_5H(CH_3)_3N_4O_2 + H_2O = 212.14$] obtained from the leaves of *Thea sinensis* Linné (Fam. *Ternstrœmiaceæ*), or from the seeds of *Coffea arabica* Linné (Fam. *Rubiaceæ*); also occurring in some other plants; or prepared synthetically.

Summarized Description.

White, flexible, silky, glistening needles, usually in fleecy masses; bitter taste; efflorescent; soluble in about 46 parts of water, in about 53 parts of alcohol also in chloroform and in ether; melts between 235° and 237°C. For details see U.S.P., p. 85.

For *tests for identity*, for *impurities*:—Organic impurities (does not color sulphuric or nitric acid more than faint yellow). Alkaloids (not precipitated by Mayer's reagent).

Color Test.—Treat caffeine with hydrochloric acid and potassium chlorate. Dried residue treated with ammonia fumes turns purple. For details see U.S.P.

Manufacture.—Made chiefly from the dust and sweepings of tea-leaves; treating a decoction of same with lead acetate, precipitating excess of lead with hydrogen sulphide, and finally concentrating solution to point at which it crystallizes.

It can also be made from tea, coffee, or guarana by cooking with litharge and water, precipitating excess of lead with hydrogen sulphide, and crystallizing. As the yield from coffee is small (0.87 to 2.0 per cent.), tea sweepings (1.5 per cent. to 3 per cent.) or guarana (5 per cent.) are generally used.

Caffeine was formerly considered an alkaloid, but is now, as mentioned above, considered as a feebly basic principle. It differs from alkaloids in not being precipitated by potassio-mercuric iodide. Like alkaloids, it forms combinations with acids, but these possess such weak union that the pharmacopœia, in the case of the one official acidulated compound, that with citric acid, does not call it caffeine citrate, but citrated caffeine.

Dose.—150 milligrammes (2½ grains).

CAFFEINÆ SODIO-BENZOAS—Caffeine Sodio-Benzoate

(Caff. Sod. Benz.)

A mixture of caffeine and sodium benzoate. It contains, when dried to constant weight of 80°C., not less than 46 per cent. nor more than 50 per cent. of anhydrous caffeine [$C_8H_{10}N_4O_2 = 194.12$], the remainder being sodium benzoate [$NaC_7H_5O_2 = 144.04$]. Preserve it in well-closed containers.

Summarized Description.

White powder; slightly bitter taste; soluble in about 1.1 parts of water (with slight decomposition), in about 24 parts of alcohol; partly soluble in chloroform; decomposed on strong, heat leaving a residue of sodium carbonate. For details see U.S.P., p. 98.

For *tests for identity*, and for *impurities:* Readily carbonizable organic matter (does not color sulphuric acid more than yellow). Heavy metals (hydrogen sulphide test), see U.S.P.

Assay.—Similar to that for citrated caffeine. For details see U.S.P., p. 98.

Remarks.—This new official caffeine compound contains from 46 to 50 per cent. of that principle and is used because of its greater solubility in water. It is therefore used, when hypodermic injections of caffeine are indicated.

Dose.—By mouth, 300 milligrammes (5 grains). Hypodermic, 200 milligrammes (3 grains).

Caffeinæ Sodio-Salicylas (N.F.) is a mixture of equal amounts of caffeine and sodium salicylate and is used like the official sodio-benzoate preparation described above.

CAFFEINA CITRATA—Citrated Caffeine

(Caffein. Cit.)

Caffeine citrate contains, when dried to constant weight at 80°C., not less than 48 per cent. of anhydrous caffeine [$C_8H_{10}N_4O_2 = 194.12.$]

Condensed Recipe.

Dissolve 50 Gm. citric acid in 100 mils of hot distilled water, add 50 Gm. caffeine and evaporate to dryness on a water-bath. For details see U.S.P., p. 86.

Summarized Description.

White powder; slightly bitter, acid taste; forms syrupy solution with small amount of water, precipitates caffeine on addition of more water, but makes a clear solution when more water is added. For details see U.S.P., p. 86.

For *tests for identity* and for *impurities.* Tartaric acid (does not color sulphuric acid more than yellow). Heavy metals (the hydrogen sulphide test), see U.S.P.

Outline of Assay.—Dissolve, make alkaline with sodium hydroxide and "shake out" with chloroform. The chloroformic solution is evaporated and the residue is dried and weighed. For details see U.S.P.

Remarks.—Citrated caffeine, as given above, is made by blending caffeine with citric acid. The union is not a definite one, like the alkaloidal salts, hence the product is called "citrated," and not "citrate of."

It is chiefly used for making the effervescent salt.

Dose.—300 milligrammes (5 grains).

CAFFEINA CITRATA EFFERVESCENS—Effervescent Citrated Caffeine

(Caff. Cit. Eff.)

It contains not less than 1.9 per cent. of anhydrous caffeine [$C_8H_{10}N_4O_2$ = 194.12].

Condensed Recipe.

Mix 195 Gm. powdered citric acid with 40 Gm. citrated caffeine and with 300 Gm. powdered tartaric acid. Then add 570 Gm. sodium bicarbonate, heat the mixture on glass plates in oven at 93° to 104°C. and when soft, granulate by rubbing through a No. 6 sieve. For details, see U.S.P., p. 87.

Outline of Assay.—Dissolve about 5 Gm. of the compound (accurately weighed) in water, make alkaline with sodium hydroxide, shake out with three portions of chloroform. Evaporate the chloroformic extract dry and weigh the residue. For details see U.S.P., p. 87.

Remarks.—Effervescent citrated caffeine is made similar to the other effervescent salts, viz., by rubbing the chemical (citrated caffeine in this case) with sodium bicarbonate, tartaric acid, and citric acid, softening mass by water-bath heat, and granulating by running through a coarse sieve. This product is a pleasant effervescent remedy for headache and nervous disorders, and is intended to replace the many proprietary preparations of similar character on the market.

Dose.—4 Gm. (60 grains).

THEOBROMINÆ SODIO-SALICYLAS—Theobromine Sodio-Salicylate

(Theobrom. Sodio-Sal.)

Sodium Theobromine [$C_7H_7O_2N_4Na$ = 202.10] and Sodium Salicylate, [$NaC_7H_5O_3$ = 160.04] in approximately molecular proportions. It yields, when dried to constant weight in a desiccator over sulphuric acid, not less than 46.5 per cent. of theobromine [$C_7H_8O_2N_4$ = 180.10]. Preserve it in well-closed containers.

Summarized Description.

White odorless powder; sweetish, saline, somewhat alkaline taste; absorbs carbon dioxide from the air and liberates theobromine; soluble in about 1 part of water; aqueous solution should be colorless and not more than opalescent; ignites on heating, leaving a residue of sodium carbonate. For details see U.S.P., p. 440.

For *tests for identity*, for *impurities:* Caffeine (alkaline solution on shaking with chloroform and evaporation of the chloroformic extract leaves not more than 0.5 per cent. of residue). Sodium carbonate (dissolves in sulphuric acid without effervescence). Organic impurities (the sulphuric acid solution only faintly colored), see U.S.P.

Outline of Assay.—The sample is first titrated with normal hydrochloric acid V.S. The resulting fluid is allowed to stand for three hours, the precipitated theobromine is collected, dried and weighed.

Remarks.—This new official compound, usually sold under the trade name, *diuretin,* is sodium theobromine salicylate, and is made by combining one molecule of sodium theobromine with one molecule of sodium salicylate. It, therefore, should contain about 49 per cent. theobromine.

It occurs in a white powder, which is comparatively unstable in air, breaking up through the loss of carbon dioxide, and for this reason diuretin should never be dispensed in powder papers. It is given as a diuretic.

Dose.—1 gramme (15 grains).

THEOPHYLLINA—Theophylline

(**Theophyll.**—Dimethylxanthine)

An organic base [$C_7H_8O_2N_4 + H_2O$ or 1 : 3 $C_5H_2(CH_3)_2 \cdot O_2N_4 + H_2O = 198.12$], isomeric with theobromine. It is found in small amounts in the leaves of *Thea sinensis* Linné (Fam. *Ternstrœmiaceæ*) and is also prepared synthetically

Summarized Description.

White crystalline powder; bitter taste; soluble in about 100 parts of water and in about 65 parts of alcohol; sparingly soluble in ether; melts between 269° and 272°C. For details see U.S.P., p. 441.

For *tests for identity,* for *impurities:* Caffeine theobromine or paraxanthine (soluble in sodium hydroxide T.S. and in ammonia water). Organic impurities (does not color sulphuric acid more than faint yellow), see U.S.P.

Remarks.—This new official compound, which is isomeric with theobromine, is found in tea but is usually made synthetically by methylating uric acid. It is a white crystalline powder, sparingly soluble in water and is a powerful diuretic. One commercial form is sold under the name, *theocine.*

Dose.—250 milligrammes (4 grains).

GUARANA—Guarana

A dried paste consisting chiefly of the crushed seeds of *Paullinia Cupana* Kunth (Fam. *Sapindaceæ*), yielding not less than 4 per cent. of caffeine.

Constituents.—Caffeine, usually 5 per cent., paullitannic acid, gum, resin, volatile oil, etc.

Remarks.—Guarana is the seed of *Paullinia Cupana,* ground up, made into a paste with water, rolled into cylinders, and dried, either by the sun or by the heat of a slow fire. Its manufacture is in the hands of the Brazilian Indians, and is most primitive. The active ingredient of guarana is the same as that found in coffee and tea—the official caffeine. The pharmacopœial assay will be explained in Part V.

Medical Properties.—Stimulant, somewhat diuretic. Administered in the form of the official *fluidextract* (p. 244), the elixir is a popular preparation, and the recipe for it will be found in the National Formulary (p. 209).

Dose.—Of drug, 2 grammes (30 grains).

Kola N.F., the seed of *Sterculia acuminata,* has lately come into popularity as a stimulant. Kola contains caffeine; theobromine; kolatin, $C_8H_{10}O_4$, crystals that oxidize to kola red; kolatein, a phenol, similar to phloroglucin.

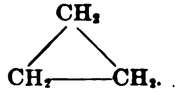
Coffea Tosta N.F., the roasted seed of *Coffea Arabica,* and **tea,** the leaves of *Thea chinensis,* also owe their activity to caffeine.

Chocolate, the ground seed of *Theobroma cacao,* and *cocoa* which represents the same seed exhausted of its fat (see oil of theobroma, p. 659) are well known as ingredients of beverages and confectionery. Besides the fat, chocolate contains theobromine, pentosans, arabinose, galactose and glucose. Cocoa is now being used extensively in pharmacy as a flavor and as a masker of the taste of bitter substances. A monograph on *cacao præparata,* or *soluble cocoa,* is given in the National Formulary.

SIMPLER RINGED COMPOUNDS

Up to this time we have considered compounds in which the carbon atoms are linked together, one after another, in the nature of the links of a chain, but even as the end links of a chain can be in turn linked, forming an endless chain or ring, so can end carbon atoms under certain circumstances be persuaded to link together, forming organic bodies of a ring nature. We have already discussed the unsaturated chain compound.

Propylene, $CH_2=CH—CH_3$, and from it can be made the isomeric *trimethylene*, having the formula



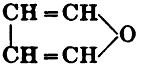
This represents the simplest ring.

In **furane**, C_4H_4O, we have a ring of four carbon atoms in which the end carbon atoms, however, are not directly combined, but are linked by aid of an oxygen atom, as shown in graphic formula.

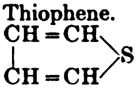
In **thiophene**, C_4H_4S, we have a similar body, in which the end carbon atoms are linked by aid of the sulphur atom.

Pyrrol, C_4H_4NH, is a similar body in which the end carbon atoms are attached by means of the NH group, these three being expressed below by graphic formulas:

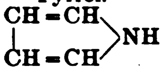
Furane.



Thiophene.



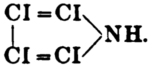
Pyrrol.



Of these three bodies, furane and thiophene are of little pharmaceutic interest, the latter substance being discovered by Victor Meyer as a constituent of benzene, with which, curious to relate, it has not merely been combined without discovery, but actually gave chemical test, which, for a long period, masqueraded as a test for the identity of benzene.

Pyrrol is of interest to us chiefly as the basis of one of the best known iodoform substitutes, *iodol*.

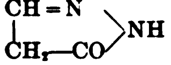
Iodol (U.S.P. VIII) discovered by Ciamician and Dennstedt in 1882, is tetraiodopyrrol, as shown by the following formula:



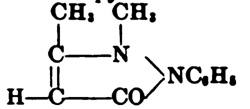
It is made by directly combining iodine with pyrrol, and has the highest iodine contents of any organic substance save iodoform, and is greatly superior to that body in being devoid of its disagreeable odor. It is a useful antiseptic.

A body of composition similar to pyrrol is *pyrazol*, and a derivative of this, phenyl-dimethyl-pyrazolon, is the valuable synthetic, *antipyrine*. Below is given the formula of each of these substances for sake of comparison:

Pyrazolon.



Antipyrine.



ANTIPYRINA—Antipyrine

(Antipyr. Phenazone)

Phenyldimethylpyrazolon [$C_{11}H_{12}N_2O$ or $C_3HN_2O(CH_3)_2 \cdot C_6H_5 = 188.12$]. Preserve it in well-closed containers.

Summarized Description.

White crystalline powder or tabular crystals; slightly bitter taste; soluble in less than 1 part of water and in about one part of alcohol; in about 1.5 parts of chloroform and in about thirty parts of ether; melts between 111° and 113°C. For details see U.S.P., p. 51.

For *tests for identity* and for *impurities* (heavy metals) see U.S.P., p. 51, and also Part V of this book.

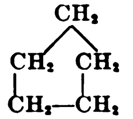
Remarks.—Antipyrine is made by treating ethyl-diacetic-ester with phenylmethyl-hydrazine. It occurs in the form of a white powder, soluble in one part of water, and melting at about 113°C. Its most likely substitute, antifebrin, melts at about the same point, but it is interesting to note that antipyrine mixed with antifebrin does not melt at 113°C., but at 45°C., so the melting-point is a valuable means of detecting admixture. When antipyrine is triturated with sodium salicylate or with chloral hydrate, it liquefies.

Antipyrine is one of the most valuable of the antipyretics, the consumption in America and Europe being enormous. It was not recognized by the pharmacopœia until the eighth revision, as it was a monopoly, the patent being controlled by a German chemical firm. Its use is not free from danger, hence pharmacists should be careful in recommending it. In fact, it should not be administered except by direction of a physician.

Dose.—300 milligrammes (5 grains).

The large demand for antipyrine gave rise to the manufacture of chemicals of similar character. Among these are *benzopyrine* (antipyrine benzoate), *salipyrine* (antipyrine salicylate), and *iodopyrine,* with an atom of iodine replacing an atom of hydrogen in phenyl compound. *Hypnal* is a combination of antipyrine and chloral.

We have just mentioned ring compounds containing three and four carbon atoms respectively; a similar ring body, containing five carbon atoms, is pentamethylene:

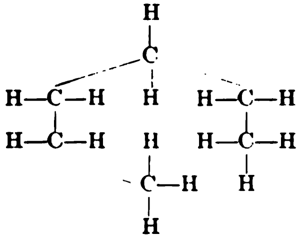


This is of no interest in pharmacy, and is merely mentioned as a step toward the ring compounds of real value—those possessing six carbon atoms.

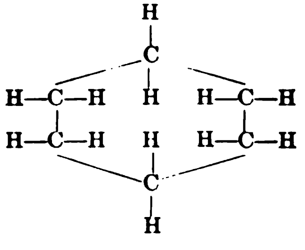
The saturated ring compound having six carbon atoms has the formula C_6H_{12}.

This body can be considered as hexane (C_6H_{14}) (Formula I), with a hydrogen atom from each end carbon atom, which are then linked by the free bonds, giving the structure shown in Formula II.

FORMULA I.



FORMULA II.



This body, C_6H_{12}, is called hexamethylene or hexahydrobenzene.

HEXAMETHYLENAMINA—Hexamethylenamine

(Hexam.—Hexamethylene-tetramine)

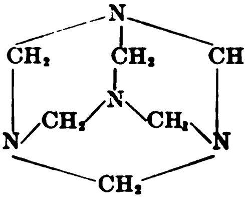
A condensation product of ammonia and formaldehyde, hexamethylene-tetramine [$(CH_2)_6N_4$ = 140.14]. Preserve it in well-closed containers.

Summarized Description.

Colorless, lustrous crystals or white crystalline powder; soluble in about 1.5 parts of water; in about ten parts of alcohol and in about 230 parts of ether; sublimes at 263°C. without melting, partially decomposing. For details see U.S.P., p. 212.

For *tests for identity* and for *impurities* (heavy metals, sulphate, chloride, ammonium salts) see U.S.P., p. 212 and also Part V of this book.

Remarks.—While hexamethylenetetramine can in some respects be best discussed at this place, from the purely chemical standpoint it might be better considered as a condensation product of formaldehyde, from which it is made. In truth, it has but little in common with hexamethylene, discussed above, its structure being quite different from that chemical, its graphic formula being—



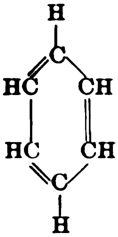
It is known in commerce as *cystogen*, *formin*, *urotropin*, etc., and is used as a uric-acid solvent and urinary antiseptic.

Dose.—250 milligrammes (4 grains).

From hexamethylene (C_6H_{12}) it is but a simple step (theoretically) to benzene, C_6H_6 (or benzol).

If from the graphic formula of hexamethylene given above the six hydrogen atoms inside the hexagon are removed, and freed bonds of the carbon atoms are linked, we get the formula of benzene:

FORMULA III.



Observe in the latter formula we have a hexagon or ring of six carbon atoms, each linked to one neighbor by one bond, and to the other by two or by "a double bond," as we say. We have stepped from the fatty to the aromatic hydrocarbons—from the chain to the ring series.

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CHAPTER XLIII

THE AROMATIC SERIES

BENZENE AND ITS DERIVATIVES

UP to this page, Part IV has been devoted to the chain or fatty series, they being so called because a large number of their compounds were of fatty character. The next class of organic chemicals to consider is the aromatic series; so called because, among them, are found most of the aromatic substances in general use. All contain as a nucleus a ring compound, based on the benzene type of hydrocarbons. For convenience, those compounds like benzene, (where the "ring" is made up of carbon atoms only) are called orthocyclic, while those containing elements other than carbon, like pyridine (p. 795) are called heterocyclic.

The graphic formula of benzene given in the preceding chapter is the one generally accepted, it answering best all the requirements of a body having the formula C_6H_6.

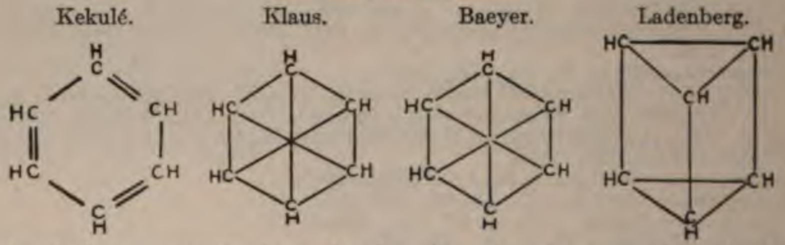
This formula is the one suggested by Professor Kekulé, of Bonn, whose work on this very difficult subject has given him a place among the great philosophers, and one of the most striking proofs of the truth of Kekulé's formula is the fact that it has withstood the criticism of fifty years, and is more firmly accepted now than ever before.

The chief difficulty of ascribing graphic formulas of the body C_6H_6 was found in reconciling the formula to the tetravalency of the carbon atoms. As shown on the preceding page, there is known a ring compound containing six carbon atoms united by single bonds. This means two hydrogen atoms attached to each carbon atom, a body having the formula C_6H_{12}. For a body to have the formula C_6H_6 means that every one of the six carbon atoms will have one unsaturated bond, a theory first advanced by Kekulé.

Other graphic formulas for benzene have been suggested, and these are pictured below. Thus, in Klaus' formula, the extra bonds of the carbon atoms are placed diagonally from carbons to carbon atom.

Baeyer considers these extra bonds as gravitating toward the center of the compound without forming a distinct union with any other bond, while Ladenberg assumes a totally different form, pictured below and called the prism form:

BENZENE FORMULAS.


Kekulé. Klaus. Baeyer. Ladenberg.

Each of these separate formulas has its advantages, and each shows some difficulties in reconciling them to the facts. And, after all the arguments are weighed, the time-honored Kekulé formula seems the most satisfactory.

Benzene is what is commercially called benzol, preference being given to the first name, because of the desire to limit the termination "ol" to the alcohols. In this case the change is unfortunate, inasmuch as it leads to confusion between this aromatic body and the official benzin, which is a petroleum product, of character totally different from the benzene of which we are now speaking.

Benzene was discovered by Faraday in 1825. It was found in coal-tar in 1845 by Hoffman, whose researches into the formation of dye-stuffs was a wonderful impetus to the benzene industry. Benzene can be made by distilling benzoic acid with chalk, but now practically the entire output is from coal-tar, that side-product in the manufacture of coal-gas from which so many valuable synthetics have been made in recent years.

Benzene in itself has comparatively limited use, being employed almost entirely as a solvent for fats and the like. Its derivatives, however, are very numerous, and many of them of great commercial value.

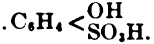
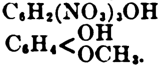
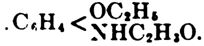
The statement given above of the danger of confusion of benzene with benzin makes a simple test of distinction between these two bodies advisable, and this we have in their action on carbolic acid. Benzin does not dissolve phenol, while benzene does. By treating benzene with concentrated nitric acid and subsequent distillation we are able to replace one of the hydrogens of benzene by an NO_2 group, giving us nitrobenzene, $C_6H_5NO_2$, which is commercially called *oil of mirbane,* and very erroneously called *artificial oil of bitter almond,* by reason of its somewhat similar odor. Oil of mirbane is used as a perfume for cheap soap.

Phenols are a class of alcohols peculiar to the benzene series, the hydroxyl being attached directly to the benzene nucleus, and its simplest example is the ordinary phenol, which is generally known as carbolic acid, and which can be considered as the hydroxide of *phenyl,* the latter word being the designation of the radicle, C_6H_5. These phenols are like alcohols, inasmuch as they form ethers, an example of which is the phenyl methyl ether, $C_6H_5OCH_3$, commercially known as anisol, and, like the alcohols, form esters, an example of which is the official salol (phenyl salicylate). However they are unlike the primary alcohols, inasmuch as they do not oxidize to aldehydes, and in most reactions will resemble the tertiary alcohols, it being a very difficult matter to oxidize same, although ketones are sometimes formed.

As stated above, the best known phenol is what is known as carbolic acid, and this is called an "acid" because it forms salts with the alkalis. From it, for example, we obtain sodium carbolate (C_6H_5ONa) and potassium carbolate (C_6H_5OK). It must be recalled, however, that even the alcohols of the chain series yield similar compounds, for instance, sodium alcoholate, C_2H_5ONa (p. 591). The carbolate, however, differs from the alcoholate, inasmuch as this can be made from carbolic acid by simply treating with alkali, whereas to make a sodium compound from alcohol requires treatment with the metal itself.

The phenols possess most of the reactions of the benzene nucleus from which they are derived; that is, the hydrogen of the benzene nucleus can be replaced by chlorine, the NO_2 group, and the like. An official illustration of such a modified phenol obtained is sodium sulphocarbolate (p. 439).

The following derivatives of benzene are of interest in pharmacy:

Phenol, U.S.P	C_6H_5OH.
Liquefied phenol, U.S.P.	87 per cent. solution of phenol.
Crude carbolic acid, U.S.P. 1890.	
Anisol	$C_6H_5—OCH_3$.
Phenolsulphonic acid	 $C_6H_4 < \genfrac{}{}{0pt}{}{OH}{SO_3H}$.
Trinitrophenol, U.S.P.	$C_6H_2(NO_3)_3OH$.
Guaiacol, U.S.P.	 $C_6H_4 < \genfrac{}{}{0pt}{}{OH}{OCH_3}$.
Guaiacol carbonate, U.S.P.	$(C_6H_4OCH_3O)_2CO$.
Resorcinol, U.S.P	$C_6H_4(OH)_2$.
Pyrogallol, U.S.P.	$C_6H_3(OH)_3$.
Anilin	$C_6H_5NH_2$.
Methelthionine hydrochloride, U.S.P	$C_{16}H_{18}N_3SCl. + 3H_2O$
Sodium indigotin disulphonate, U.S.P.	$C_{16}H_8O_2N_2(SO_3Na)_2$
Acetanilide, U.S.P.	$C_6H_5NHC_2H_3O$.
Acetphenetidine, U.S.P	 $C_6H_4 < \genfrac{}{}{0pt}{}{OC_2H_5}{NHC_2H_3O}$.

PHENOL—Phenol

(Carbolic Acid)

Hydroxybenzene obtained from coal-tar or made synthetically. It contains not less than 97 per cent. of C_6H_5OH (94.05). Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, interlaced, needle-shaped crystals or white crystalline masses, sometimes becoming red; characteristic, somewhat aromatic odor; strongly caustic, soluble in about fifteen parts of water; very soluble in alcohol, glycerin, chloroform, ether, carbon disulphide and in fixed and volatile oils; melts when gently warmed; congeals at 38°C.; liquefies on addition of 8 per cent. of water. For details see U.S.P., p. 316. For *assay* see U.S.P., and also Part V of this book.

Remarks.—This phenol was discovered by Runge, in 1834, as a constituent of coal-tar, from which it is separated by contact with potassium hydroxide (thus forming potassium carbolate); separation of the acid from potassium carbolate by treating with sulphuric acid and fractional distillation of the freed product. Carbolic acid has also been made synthetically from benzene by conversion of benzene into sodium phenolsulphonate, $C_6H_5SO_3Na$, and fusing this with sodium hydroxide, when sodium carbolate and sodium sulphite are produced:

$$C_6H_5SO_3Na + 2NaOH = C_6H_5ONa + Na_2SO_3 + H_2O.$$

The official carbolic acid occurs in colorless, needle-shaped crystals having a characteristic odor and sweetish taste. It should, however, never be tasted in concentrated form.

The solubility of the crystalline carbolic acid is a matter of interest. *One hundred parts dissolve eight parts of water* to a clear liquid. If more water be added, it clouds, since the acid will dissolve no more. This cloudiness is continued until 1500 parts of water have been added, when the conditions are reversed and the water dissolves the acid.

Some of the crystalline carbolic acids, especially those of English manufacture, acquire a reddish tint on standing, and the origin of this disagreeable phenomenon has been a matter of considerable discussion. Some claim that the nitrogen of the air acts on the phenol, forming one of the numerous dye-stuffs obtained from benzene; others think it due to organic impurities, some think that copper contamination is the cause; while Gibbs states that it is due to the condensation of the phenol molecules to phenoquinone and other quinone derivatives. The removal of this color is a matter of considerable difficulty; the only perfect way is by the redistillation of the phenol, an operation that cannot be safely performed in the ordinary laboratory.

It must be borne in mind that the vapors of phenol are inflammable, and, therefore, great care should be used in melting same by means of heat; in fact, the best way to melt the substance is to dip the bottle in heated water rather than to heat the mass direct, even on a water-bath.

Carbolic acid has a number of characteristic reactions, among which may be cited the violet-blue color it gives with a drop of ferric chloride solution, its coagulating action on albumin and collodion, and the yellow precipitate with bromine. The first two tests are of interest as distinguishing between itself and creosote, carbolic acid being a frequent substitute for the more costly wood-tar product. The bromine reaction is of interest as the basis of the volumetric estimate of carbolic acid (see Part V).

As mentioned above, carbolic acid can be liquefied by addition of 8 per cent. of water. This solution, however, is scarcely as desirable as one liquefied by an addition of a small quantity of alcohol although even that may be objectionable on account of possible irritating qualities of the alcohol. This solution, the so-called 95 per cent. carbolic acid, is what is generally dispensed in answer to calls for pure carbolic acid instead of the crystals themselves. The extended use of this 95 per cent.

carbolic acid by suicides, and the almost invariable fatal results from use in this way, has brought about legislation in several parts of this country prohibiting its sale except upon a physician's prescription.

Carbolic acid is one of the most valuable of all antiseptics, its germicidal action being due to the fact that it coagulates albumin. In full strength it is, as mentioned above, a very caustic poison. The antidotes are syrup of lime, or a tumblerful of solution of potassium permanganate, 1 in 1000, or gastric lavage with 10 per cent. alcohol. For phenol burns, the skin should be washed with alcohol, ether, glycerin, or oils. The latter should never be used internally as an antidote.

The official preparations of carbolic acid are a 2.25 per cent. ointment and the glycerite, which contains 20 per cent. of phenol. In some sections *carbolic oil*, made by combining phenol with either olive oil or cotton seed oil, in proportions from one to nineteen, is a favorite remedy for cuts and sores. The National Formulary recognizes this preparation under the title, *Oleum phenolatum.*

Dose.—60 milligrammes (1 grain).

PHENOL LIQUEFACTUM—Liquefied Phenol

(Phenol Liq.—Liquefied Carbolic Acid)

A liquid containing not less than 87 per cent. of C_6H_5OH (94.05).

Condensed Recipe.

Liquefy phenol by heating an uncorked container on a water-bath, then add one part of distilled water to each nine parts of phenol. For details see U.S.P., p. 317.

Summarized Description.

Colorless liquid, sometimes turning red on standing; characteristic, somewhat aromatic odor; very caustic, whitening skin and mucous membrane; miscible with alcohol, ether or glycerin; miscible with water only after admixture with glycerin; sp. gr. 1.065; boils not higher than 182°C. For details see U.S.P., p. 317.

For *tests for identity,* for *impurities* and for *assay,* see phenol and also Part V of this book.

Remarks.—As mentioned under Phenol, that chemical forms a permanent liquid by the addition of from 8 to 10 per cent. water, and this liquid has been given pharmacopœial recognition. Its use is, of course, the same as phenol.

Dose.—0.05 mil (1 minim).

Phenol Iodatum (N.F.), or *iodized phenol,* is made by warming together iodine (20 per cent.), phenol (60 per cent.) and glycerin.

Liquor Iodi Phenolatis (N.F.), or *Boulton's solution,* is a colorless mixture made from liquefied phenol (6 mils to the liter) compound solution of iodine, glycerin and water. Phenol being an unsaturated body, absorbs the iodine even as benzene does, and the iodine compound is colorless.

Acidum Carbolicum Crudum (U.S.P. 1890).—*Crude carbolic acid* is a liquid consisting of various constituents of coal-tar obtained by fractional distillation. The official crude carbolic acid is a nearly colorless or reddish or brownish-red liquid, and possesses a characteristic odor. The true carbolic acid ordinarily sold in stores represents a very dirty black liquid, which has but little value, as it is notoriously weakened by addition of water. Crude carbolic acid is used entirely as a disinfectant, for which purpose it is better than the crystals, because it contains a large quantity of cresol in addition to its chief constituent, phenol.

Anisol, $C_6H_5OCH_3$, as mentioned above, is phenylmethyl-ether. We have already learned that if methyl alcohol and ethyl alcohol are combined in the presence of sulphuric acid, there will be yielded methyl-ethyl-ether, and in the same way if methyl alcohol and phenol are mixed in the presence of sulphuric acid, methylphenyl-ether, or anisol, is produced. As its name suggests, it can be derived from oil of anise. During the European War, anisol was found to be a valuable remedy for body vermin.

As the consideration of methyl salicylate was deferred until we had discussed salicylic acid, it is consistent to refer the official *phenyl salicylate,* or *salol,* to the same heading.

TRINITROPHENOL—Trinitrophenol

Trinitrophen.—Picric Acid)

Trinitrophenol [$C_6H_3O_7N_3$ or $C_6H_2(OH)(NO_2)_3$ 1:2:4:6 = 229.05.] **Preserve it** in well-stoppered bottles, in a cool place, remote from fire.

Caution.—For safety in transportation it is usually mixed with about 20 per cent. of water. Before applying the tests described below dry the Trinitrophenol to constant weight in a desiccator over sulphuric acid.

Summarized Description.

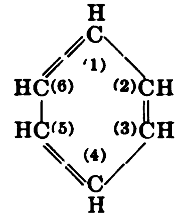
Pale-yellow, rhombic prisms or scales; intensely bitter taste; explosive; soluble in about 78 parts of water, in about 10 parts of alcohol, and also in chloroform, ether and benzene; melts between 121° and 123°C. For details see U.S.P., p. 471.

For *tests for identity* and for *impurities* (sulphate) see U.S.P., and also Part V of this book.

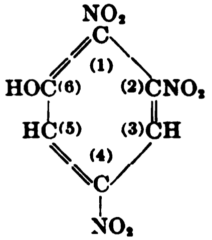
Remarks.—This substance is phenol in which three of the hydrogen atoms of the benzene nucleus are replaced by NO_2 groups, these groups replacing the hydrogen attached to carbon atoms one, two, and four respectively.

At this place it might be stated that, for purposes of convenience, chemists have numbered the carbon atoms of the benzene ring as shown below:

Benzene.



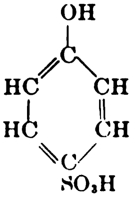
Picric acid.



Picric acid is made by treating trinitrobenzene with potassium ferricyanide. It appears in bright yellow crystals, soluble in water, having a strong acid character, and very explosive, hence should be handled by the pharmacist with the utmost care. It is used as a dye for silk, as an explosive and as reagent for alkaloids, albumin and sugar. In medicine, it is used occasionally as an antiperiodic, while a 2 per cent. hydro-alcoholic solution is now quite popular as an application for burns.

Dose.—30 milligrammes (½ grain).

Sulphocarbolic acid (or phenol sulphonic acid) is a body prepared by treating carbolic acid with sulphuric acid. Its composition is best understood from the graphic formula:



The official sodium salt of this acid is made by treating mixture of sulphuric acid and carbolic acid with barium carbonate, whereby solution of barium sulphocarbolate is produced, and this solution, on being treated with a molecular quantity of sodium carbonate, produces sodium sulphocarbolate, while the barium is precipitated as barium carbonate. (See Sodium Compounds, p. 439.)

Soziodol represents sulphocarbolic acid in which two of the hydrogen atoms of the benzene nucleus have been replaced by iodine, and, indeed, those hydrogens attached to the carbon atoms numbers two and six.

This is used as an antiseptic in the form of ammonium, barium, lead, and other metallic salts.

Sozol is a trade name for aluminum sulphocarbolate.

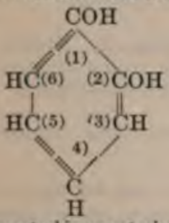
Aseptol is an aqueous solution of orthosulphocarbolic acid. This body differs from sulphocarbolic acid, mentioned above, in having the hydroxyl and sulphonic acid (SO_3H) groups on adjoining carbon atoms, this distinction between ortho-, meta-, and para-compounds being reserved for discussion later.

DIATOMIC PHENOLS

As we already learned when considering the fatty series, besides alcohols containing one hydroxyl, similar bodies have been found containing two, three, and even more hydroxyls, these being examples of polyatomic alcohols. Thus, glycerin, which, it will be recalled, has the formula $C_3H_5(OH)_3$, is a polyatomic alcohol. In the same way we can have polyatomic phenols.

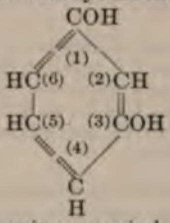
The simplest of these phenols are the diatomic—those possessing two hydroxyl groups. The direct benzene derivatives of this class have the formula $C_6H_4(OH)_2$, and with this, as with all di-derivatives of benzene, we have three types, based on the relative positions of the two substituted radicles. Taking $C_6H_4(OH)_2$ as example, we can best explain the three modifications by the graphic formulas given below:

Ortho-dioxbezene.



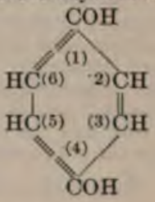
Pyrocatechin or catechol.

Meta-dioxybenzene.



Resorcin or resorcinol.

Para-dioxybenzene.



Hydroquinone or quinol.

It will be seen that the *ortho*-body is one in which the two hydroxyl groups are on adjoining carbon atoms; the *meta-* is the one in which one carbon atom intervenes between the two hydroxyl groups on one side, and three on the other, whereas the *para*-compounds have two carbon atoms intervening between the hydroxyl groups.

Possibly a clearer explanation of this is by numbering the carbon atoms as above, and saying that in the ortho-body the hydroxyl groups are attached to carbon atoms number one and two; in the meta-, the hydroxyl groups are attached to carbon atoms number one and three; and in the para-bodies, the hydroxyl groups are attached to carbon atoms number one and four.

It is hardly necessary to note that this numbering is purely arbitrary, and that a benzene in which two radicles are attached to carbon atoms four and five would be as much ortho- as is that attached to one and two as given above.

Of the three diatomic phenols having the formula $C_6H_4(OH)_2$, the ortho-compound is called pyrocatechin; the meta-, resorcin, and the para-, hydroquinone.

Pyrocatechin, obtained by destructive distillation of catechin, is a constituent of catechu, U.S.P. 1890. It is of no pharmaceutic value. The methyl ether of same, however, is guaiacol.

GUAIACOL—Guaiacol

The monomethyl ether [$C_7H_8O_2$ or $C_6H_4(OH)OCH_3$) 1 : 2 = 124.06], or orthodihydroxybenzene, obtained from wood-tar creosote or prepared synthetically. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless or yellowish, strongly refractive liquid or crystalline solid; agreeable aromatic odor; turns darker in exposure to light; soluble in about 53 parts of water and in about one part of glycerin; miscible with alcohol, chloroform ether or acetic acid; sp. gr. of liquid form, 1.112 to 1.114; melting point of solid form, 28°C.; at least 85 per cent. distils between 200° and 210°C.

For *tests for identity* and for *impurities.*

Oily hydrocarbons (alkaline solution should not be turbid) see U.S.P., p. 210 and also Part V of this book.

Remarks.—This substance can be made synthetically by cooking pyrocatechin with a mixture of potassa and potassium methyl sulphate, although it is usually prepared commercially by the rectification of creosote.

Guaiacol is one of our most valuable internal antiseptics, and for this purpose is used both in tuberculosis and also in intestinal troubles.

Dose.—0.5 mil (8 minims).

GUAIACOLIS CARBONAS—Guaiacol Carbonate

(Guaiacol. Carb.)

A guaiacol derivative [$(C_7H_7O)_2CO_3$ or $(C_6H_4(OCH_3)O)_2.CO$ = 274.11].

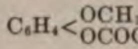
Summarized Description.

Crystalline powder; odorless and tasteless or else slightly aromatic; soluble in about 48 parts of alcohol, in abouts 1.5 parts of chloroform and in about 13 parts of ether; slightly soluble in glycerin and fixed oils; quite soluble in benzene; melts between 83° and 87°. For details see U.S.P., p. 210.

For *tests for identity*, for *impurities* see guaiacol (the guaiacol being separated from the carbonate by saponification.)

Remarks.—This solid derivative of guaiacol is known as *duotal.* Its use is similar to guaiacol, over which it possesses the advantage of being less irritating.

Dose.—1 gramme (15 grains).



Benzozol, $C_6H_4<\substack{OCH_3\\OCOC_6H_5}$, is the benzoic acid ester of guaiacol, and is used like it.

RESORCINOL—Resorcinol

(Resorcin.—Resorcin)

Metadihydroxybenzene. It contains not less than 99.5 per cent. of $C_6H_4(OH)_2$ 1 : 3 (110.05). Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, needle-shaped crystals or colorless powder; peculiar odor; sweetish, then bitter taste; turns pink on exposure to light and air; soluble in about 0.9 part of water and in about 0.7 part of alcohol; quite soluble in glycerin or ether, slightly soluble in chloroform; melts between 109° and 111°C. For details see U.S.P. p. 360.

For *tests for identity* and for *impurities:* Catechol (no precipitate with lead acetate) see U.S.P., p. 360.

This body, metadihydroxybenzene, was discovered by Hlasiwitz in 1864, who obtained it by fusing galbanum with potassa. It can be made in the same way from other gum-resins, such, for example, as asafetida, and is now prepared synthetically by fusing metadisulphonbenzene, $C_6H_4(SO_3H)_2$, with potassa.

Resorcinol occurs in white, feathery crystals, turning pinkish on exposure to air; soluble in water, alcohol, and ether. It is used chiefly externally in some forms of skin troubles because of its antiseptic action. Of late it has had considerable vogue as a cure for dandruff. When taken internally, it possesses antipyretic properties.

Dose.—125 milligrammes (2 grains).

Euresol, or resorcin monoacetate has been recommended in dermatology and for use in hair tonics.

Thioresorcin, $C_6H_4O_2S_2$, was suggested as an iodoform substitute, but has been abandoned on account of its harmful action.

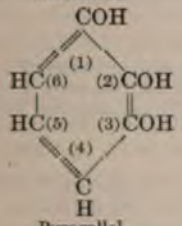
Resopyrin represented a fused mass of resorcinol with antipyrin, and was used as an antipyretic.

Resorcinol is made by fusing iodoform with resorcin. The name of this is unfortunate, inasmuch as the word resorcinol is the correct modern appellation for resorcin itself.

Hydroquinone is the paradioxy-derivative of benzene, and is obtained by oxidation of cinchonic acid. It is also obtained by hydrolysis of the glucoside arbutin (p. 640). It has practically no medicinal application, although very largely used in photography.

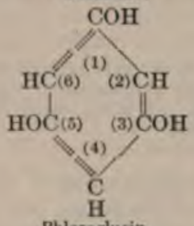
Triatomic phenols of benzene have the formula $C_6H_3(OH)_3$. As there were three diatomic phenols, so there are three bodies with the formula $(C_6H_3(OH)_3$, and the graphic formulas of these are given below:

Vicinal trioxy-
benzene.



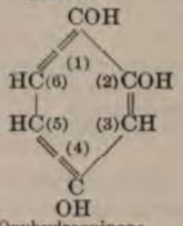
Pyrogallol.

Symmetric trioxy-
benzene.



Phloroglucin.

Asymmetric trioxy-
benzene.



.Oxyhydroquinone.

As will be noticed, in the vicinal form, the three hydroxyl groups are on adjoining carbon atoms; in the symmetric, the hydroxyl groups are each separated from the other by an interposed carbon atom; while in the asymmetric two are on adjoining carbon atoms and the other is separated by an interposed carbon atom.

In explaining it in the numeric way, in the vicinal the hydroxyl groups are on carbon atoms 1, 2, and 3; in the symmetric, they are on carbon atoms 1, 3, and 5, and in the asymmetric they are on carbon atoms 1, 2, and 4.

As the classification for the ortho-, meta-, and para-compounds applies to all di-derivatives of benzene, so also the classification of the vicinal, symmetric, and asymmetric applies to all tri-derivatives of benzene.

As noted above, the three tribasic phenols are called pyrogallol, phloroglucin, and oxyhydroquinone respectively.

PYROGALLOL—Pyrogallol

(**Pyrogall.**—Pyrogallic Acid)

Trihydroxybenzene [$C_6H_3(OH)_3$ 1 : 2 : 3 = 126.051]. Preserve it in well-closed containers, protected from light.

Summarized Description.

White or nearly white laminæ or fine needles; bitter taste; turns grayish on exposure to light and air; soluble in about 1.7 parts of water, in about one part of alcohol and in about 1.1 parts of ether; melts between 129° and 133°C. For details see U.S.P., p. 348.

Remarks.—Pyrogallol is what is commercially called pyrogallic acid, and was discovered by Scheele in 1786. It is made by strongly heating gallic acid, hence the name, pyrogallic acid; the prefix, *pyro*, as explained on p. 429, communicating the idea that the body has been produced by strong heat.

As will be explained under gallic acid, the heating of that product causes the loss of CO_2, with formation of the official pyrogallol.

Pyrogallol is in light white needles, becoming gray or darker on exposure to air and light. It is soluble in 1.7 parts water and one part alcohol; melts at between 129° and 133°C., subliming at the same time.

Pyrogallic acid is one of the most valuable reducing agents, having such strong affinity for oxygen that one volume of 2½ per cent. alkaline solution absorbs 14 volumes of the gas, and for this reason it is used as an absorber in gas analysis. Its reducing action makes it valuable as a developer in photography, and it has of late been considerably used as one of the constituents of that class of hair-dyes producing auburn or chestnut tints. These dyes consist of two solutions, one of either copper or nickel salts, and the other, pyrogallol, and when the hair is moistened with the solution of metallic salt and then treated with pyrogallol solution, a literal "copper plating" takes place.

Pyrogallol is used externally in skin troubles, but should be applied only under the direction of skilled physicians, as it is decidedly irritating in action.

Phloroglucin, $C_6H_3(OH)_3$ 1:3:5, is made by fusing kino with potassa or resorcin with soda. It is of no pharmaceutic value save as a test for wood-paper (p. 632).

Oxyhydroquinone, $C_6H_3(OH)_3$ 1:2:4, is an oxidation product of quinine, but of no value either in medicine or pharmacy.

The amido derivatives of benzene are of almost equal importance to the hydroxyl derivatives, $C_6H_5NH_2$ being the well-known aniline.

Aniline was discovered as a distillation product from indigo by Helot in 1740; its presence in coal-tar was demonstrated by Runge in 1824; while Fritsche investigated the coal-tar derivative in 1841, found it identical with the product from indigo and called it aniline, from the Portuguese name for indigo, "anil." The chemistry of the subject was not made perfectly clear until Hoffman's investigations of 1843, and the further researches of this master gave rise to our present dye-stuff industry, with its enormous capital and its far-reaching influence.

While the first aniline dye-stuff, mauvein, was manufactured by Perkin in 1856, it was not until 1864 that the manufacture of aniline reached a commercial basis, and in that year the first aniline factory was established. While aniline itself is a constituent of coal-tar, it has been found simpler to convert the benzene distillate of coal-tar into the body by first changing same into nitrobenzene, $C_6H_5NO_2$, and reducing this to aniline, $C_6H_5NH_2$, by treating with hydrochloric acid and iron filings. The product of the reduction is then distilled with steam and purified by repeated distillation if necessary.

Aniline is a straw-colored liquid possessing a peculiar aromatic odor, somewhat similar to benzene; soluble in 31 parts of water and is neutral to litmus-paper. It possesses valuable solvent properties—dissolving indigo, for instance. Its reactions are manifold, they leading to that exceedingly valuable class of compounds, the dye-stuffs, which at present have assumed such proportions as to make their study a science in itself, and far beyond the scope of this work.

Aniline dyes (so called) are not all simple derivatives of aniline. In fact, among the thousands of these dyes that are now so important a factor in the world's commerce, but few of them are really obtained directly from aniline. A discussion of these dyes is beyond the limits of this book but there are a few that must be discussed because of their pharmaceutic significance and all of these will be considered in this chapter.

METHYLTHIONINÆ CHLORIDUM—Methylthionine Chloride

(Methylthionin. Chlor.—Methylthioninæ Hydrochloridum, U.S.P. VIII —Methylene Blue)

Tetramethylthionine chloride [$C_{16}H_{18}N_3ClS + 3H_2O = 373.75$].

Summarized Description.

Dark-green crystalline powder or prismatic crystals with bronze-like luster; soluble in water, alcohol and chloroform, forming blue solutions; aqueous solution lessened in color by addition of hydrochloric acid, and is turned purple by sodium hydroxide with eventual precipitation; zinc and diluted sulphuric acid reduce it to a colorless compound. For details see U.S.P., p. 273.

For *tests for identity and for impurities:* Dextrin (not more than 1 per cent. insoluble in boiling alcohol). Arsenic and zinc (usual tests) see U.S.P. and also Part V of this book.

Remarks.—The manufacture of methylene-blue opens up the complex question of synthetic aniline dyes. Aniline (Formula I) can be converted into paraphenylenediamine (Formula II), and this in turn can be methylated to dimethylparaphenylenediamine or para-amidodimethyl aniline (Formula III). When this substance is treated with hydrogen sulphide and ferric chloride, two molecules condense and add sulphur (Formula IV), forming one molecule of methylene-blue (Formula V).

FORMULA I.

$C_6H_5NH_2$

Aniline.

FORMULA II.

$C_6H_4(NH_2)$

-phenylenediamine.

FORMULA III.

$H_2N—C_6H_4—N(CH_3)_2$

Dimethylparaphenylenediamine.

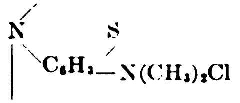
FORMULA IV.

$H_2N\ C_6H_4N(CH_3)_2$

$HHNC_6H_4N(CH_3)_2$

Condensation of dimethylparapheny enediamine (ammonia splits off).

FORMULA V.



Methylene-blue.

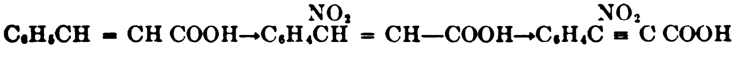
The commercial methylene-blue is a double salt of the pure dye with zinc chloride, hence must not be used. This explains the test for its presence given in the pharmacopœia.

Methylene-blue is used as an antiseptic in gonorrhea. It is very disagreeable to handle, because it stains everything with which it comes in contact a tenacious blue, which washing in water or alcohol will eventually remove.

Dose.—150 milligrammes (2½ grains).

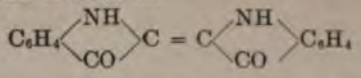
Indigo is an important dye-stuff originally obtained from plants of the *Indigofera* species. It is now made synthetically upon a commercial scale by the reduction of ortho-nitro-phenyl-propiolic acid with glucose or with xanthogenates. The acid just mentioned is derived from cinnamic acid and in order to show the structure of indigo, the synthesis will be shown by formulæ below:

Cinnamic acid. Ortho-nitro-cinnamic acid. Ortho-nitro-phenyl-propiolic acid.



$$C_6H_5CH = CH\ COOH \rightarrow \overset{NO_2}{C_6H_4}CH = CH—COOH \rightarrow \overset{NO_2}{C_6H_4}C \equiv C\ COOH$$

From two molecules of the latter acid by reduction is obtained one molecule of indigo; the graphic formula of which is:



$$C_6H_4\langle{}^{NH}_{CO}\rangle C = C\langle{}^{NH}_{CO}\rangle C_6H_4$$

SODII INDIGOTINDISULPHONAS—Sodium Indigotindisulphonate

(Sod. Indigotin.—Indigo Carmine)

Chiefly the sodium salt [$C_{16}H_8O_2N_2(SO_3Na)_2$ = 466.22] of indigotindisulphonic acid.

Summarized Description.

Blue powder or dark purple paste with coppery luster when dry and compressed; sparingly soluble in water, giving a dark blue solution; almost insoluble in alcohol. For details see U.S.P., p. 391.

For *tests for identity*, for *impurities:* Starch or starch iodide (aqueous solution bleached with bromine water does not turn blue on addition of potassium iodide) see U.S.P., p. 392. Iron ferrocyanide and ferricyanide (see Part V of this book).

Remarks.—This dye was introduced into the present pharmacopœia merely because it is used to color *poison tablets of corrosive mercuric chloride* (p. 318). It is commonly called *indigo carmine* or *soluble indigo.* Indigo is insoluble in water and in order to make it water-soluble, it is first treated with concentrated sulphuric acid, producing indigotin-disulphonic acid [$C_{16}H_{18}O_2N_2(SO_3H)_2$] and then this is converted into the less corrosive sodium salt, $C_{16}H_{18}O_2N_2(SO_3Na)_2$. Indigo carmine is marketed either in the form of a powder or paste.

Scarlet Red (N.N.R.) or *Biebrich scarlet R*, is tolyl-azo-betanaphthol, $CH_3C_6H_4N = N—C_6H_3(CH_3)N = N—C_{10}H_6OH$. It has been used rather extensively during the past few years for promoting the growth of epithelium in cases of burns. For this purpose an ointment consisting of 8 parts of scarlet red, 2 parts of eucalyptol and 90 parts of petrolatum is employed.

ACETANILIDUM—Acetanilid

(Acetanil.—Acetanilide—Antifebrin)

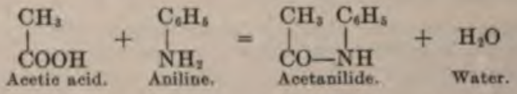
The monoacetyl derivative [C_8H_9NO or $C_6H_5NH(CH_3CO)$ = 135.08] of aniline.

Summarized Description.

Colorless, shining micaceous crystalline laminæ or crystalline powder; slightly burning taste; soluble in about 190 parts of water, in about 2.5 parts of alcohol and also soluble in chloroform, ether, benzene and glycerin; melts between 112° and 114°C. For details see U.S.P., p. 4.

For *tests for identity*, for *impurities:* Readily carbonizable matter (does not color sulphuric acid more than yellow). Aniline salts (does not darken ferric chloride). See U.S.P.

Remarks.—This body, commonly called *antifebrin*, represents aniline in which one of the hydrogen atoms is replaced by the acetyl (C_2H_3O) group. It is made by heating aniline with glacial acetic acid, the reaction being—



$$\underset{\text{Acetic acid.}}{\begin{matrix}CH_3\\|\\COOH\end{matrix}} + \underset{\text{Aniline.}}{\begin{matrix}C_6H_5\\|\\NH_2\end{matrix}} = \underset{\text{Acetanilide.}}{\begin{matrix}CH_3\ C_6H_5\\|\quad\ |\\CO—NH\end{matrix}} + \underset{\text{Water.}}{H_2O}$$

Acetanilide, or *phenyl acetamide*, as it is sometimes called, occurs in white, shining lamina or in crystalline powder, sparingly soluble in alcohol, melting between 112° and 114°C. It, like aniline, responds to the isonitrile reaction (p. 581).

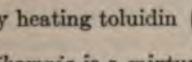
Acetanilide is one of the most valuable antipyretics, although, like all the modern synthetics of this character, it should be used with caution. The indiscriminate use of these products has caused great harm, being particularly dangerous to persons with weak hearts. It is given in doses of three to four grains, either in powder or dissolved in brandy. An excess of acetanilide produces symptoms of coma and collapse, and the best antidote is copious drafts of brandy.

Dose.—200 milligrammes (3 grains).

ACETANILIDE DERIVATIVES AND SUBSTITUTES

Bromacetanilide is formed when one of the hydrogen atoms of the benzene nucleus is replaced by bromine. It is an antipyretic and antiseptic. Dose, 1 to 8 grains.

Benzanilide.—In this the benzoyl (C_6H_5CO) group is substituted for the acetyl group in the acetanilide.

Exalgin is methyl acetanilide, or, more properly speaking, acettoluidide, and is made by heating toluidin  $\left(C_6H_4<\begin{matrix}CH_3\\NH_2\end{matrix}\right)$ with glacial acetic acid.

Antikamnia is a mixture of acetanilide, caffeine, tartaric acid, and sodium bicarbonate. A combination of this character is recognized in the National Formulary as Compound Powder of Acetanilide (p. 294).

Antinervine is a compound consisting of 50 per cent. acetanilide, 25 per cent. each ammonium bromide and salicylic acid.

ACETPHENETIDINUM—Acetphenetidin

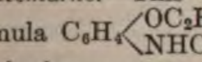
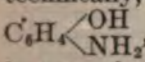
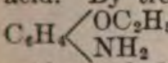
(Acetphen.—Phenacetin)

The monoacetyl derivative [$C_{10}H_{13}NO_2$ or $C_6H_4(OC_2H_5)\cdot NH\cdot CH_3CO$ 1:4 = 179.11] of para-amidophenetol.

Summarized Description.

White, glistening, crystalline scales or fine crystalline powder; slightly bitter taste with numbing effect on the tongue, soluble in about 1300 parts of water, and in about 12 parts of alcohol; also soluble in chloroform and ether; melts between 133° and 135°C. For details see U.S.P., p. 5.

For *tests for identity* and for *impurities:* Readily carbonizable matter (does not color sulphuric acid more than yellow). Acetanilide (aqueous solution not made turbid or not precipitated by bromine water). Para-phenetidin (not turned red on proper treatment with iodine solution) see U.S.P.

Remarks.—This body, commonly known as *phenacetine,* has the formula  $C_6H_4\begin{matrix}\diagup OC_2H_5\\\diagdown NHC_2H_3O.\end{matrix}$ It represents acetanilide in which one of the hydrogen atoms is replaced by an OC_2H_5 group. Speaking more technically, it represents an ethyl acetyl derivative of para-amido-phenol,  $C_6H_4\begin{matrix}\diagup OH\\\diagdown NH_2\end{matrix}$, and is made by the reduction of para-nitrophenol, which, in turn, is prepared by treating carbolic acid with cold diluted nitric acid. By treating para-amido-phenol with ethyl iodide, p-phenetidin,  $C_6H_4\begin{matrix}\diagup OC_2H_5\\\diagdown NH_2\end{matrix}$, is produced, and by treating the latter with glacial acetic acid acetyl phenetidin or phenacetine results.

Phenacetine is a white powder that melts at 134° to 135°C. It is one of the most valuable antipyretics.

Phenacetine is sometimes contaminated with phenetidin. This latter is a dangerous irritant, hence such adulterated phenacetine should not be dispensed. Detection of same is easily accomplished by the pharmacopœial test given above.

Some unscrupulous dealers have adulterated phenacetine with acetanilide, but this can be easily detected by means of the melting-point

—phenacetine, 133° to 135°; acetanilide, 112° to 114°—or by the pharmacopœial chemical test given above.

Dose.—300 milligrammes (5 grains).

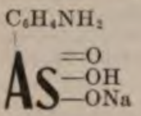
As with all the successful modern synthetics, the introduction of phenacetine was followed by a large number of bodies of similar composition. Thus we have *iodophenin*, which represents phenacetine hydrochloride combined with iodine and potassium iodide.

Methacetin, $C_6H_4<\begin{smallmatrix}OCH_3\\NHC_2H_3O\end{smallmatrix}$, differs from phenacetine only in having a methyl group instead of the ethyl group of phenacetine, and, like it, is used as an antipyretic.

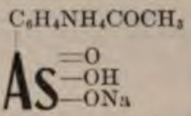
Hydracetin or *pyrodin*, $\begin{array}{c}C_6H_5-NH\\ |\\ NHC_2H_3O\end{array}$, which is acetphenylhydrazin and made similar to acetanilide, save for the use of phenylhydrazin instead of aniline.

Phenocoll hydrochloride, $C_6H_4<\begin{smallmatrix}OC_2H_5\\NHCOCH_2NH_2+HCl\end{smallmatrix}$, is made by treating phenetidin with amido-acetic acid, $CH_2<\begin{smallmatrix}NH\\COOH\end{smallmatrix}$ (glycocoll). Phenacoll hydrochloride occurs in white crystals, soluble in 20 parts of water, and in this way possesses decided advantage over phenacetine, which is soluble in 1300 parts of water, as mentioned above. It, like phenacetine, is used as an antipyretic. Strictly speaking, it might more properly be considered under the hydrocarbons other than benzene, as both phenacetine and phenocoll contain more than six carbon atoms. However, as they so closely resemble acetanilide, it was deemed advisable to deviate from the regular order, that these closely similar bodies might be considered together.

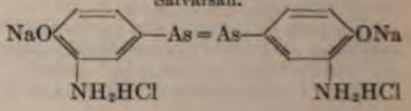
Arseno Organics.—During recent years, complex organic combinations containing arsenic have come into vogue as remedies for protozoal diseases, such as sleeping sickness, malaria and syphilis. Among the chemicals thus employed we find *Atoxyl*, or sodium arsenilate containing three molecules of water; *soamine*, or sodium arsenilate containing five molecules of water; *arsacetin*, or sodium acetyl arsenilate; *salvarsan* or "606," which is the hydrochloride of the sodium compound of dioxy-diamido-arsenobenzene; and *neosalvarsan* which is the sodium combination of dioxy-diamino-arsenobenzene-methanal-sulphoxylate. The structural formulæ of the three that are of most importance are given below:


Sodium arsenilate.

$$\begin{array}{l}C_6H_4NH_2\\ |\\ As\begin{smallmatrix}=O\\-OH\\-ONa\end{smallmatrix}\end{array}$$


Arsacetin.

$$\begin{array}{l}C_6H_4NH_4COCH_3\\ |\\ As\begin{smallmatrix}=O\\-OH\\-ONa\end{smallmatrix}\end{array}$$


Salvarsan.

From these formulas, it will be seen that the first two are combinations of aniline and acetanilide with arsenic acid while "606" has as its basis a body $C_6H_5As=As-C_6H_5$ which is analogous to that largely used aniline derivative, azo-benzene $C_6H_5N=N-C_6H_5$. Salvarsan is clearly the most important of the compounds just described. It is made by treating phenol with nitric acid, thereby obtaining para-oxy-phenyl arsenic acid. This is nitrated and the nitro-body is then reduced with sodium amalgam to amino-phenyl arsenic acid. This substance on treatment with sodium hydroxide, sodium hydrosulphite and magnesium chloride yields di-amido-dioxy-arseno-benzene, the hydrochloride of which is the commercial salvarsan.

Salvarsan is a yellow, crystalline, hygroscopic powder, that is so unstable in air, that it has to be marketed in ampuls. Its introduction has opened a new field of activity for those pharmacists having the ability and inclination to prepare the ampulled chemical into an exactly neutral, sterile solution for intravenous administration. There have been a number of methods suggested (see bibliography), the simplest being as follows:

The weighed quantity of salvarsan (the commercial ampuls each contain a 0.6-gramme dose) is triturated with 0.7 mil of sterile normal sodium hydroxide solution for each 0.1 gramme of salvarsan employed and then more of the alkaline solution is added, drop by drop, until complete solution occurs. This solution is then diluted with 100 to 250 mils of sterile physiologic salt solution (0.9 per cent.) after which it is filtered through a sterile filter. It is needless to say that the operation should be performed under absolutely aseptic conditions; that all the material and utensils should be sterile and that the room and the operator should be as near germ-free as possible. The dose of salvarsan is 0.3 to 0.6 gramme (5 to 9 grains).

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Exalgine.—Hepp and Hoff, B., 10, 1877, 328.

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Phenacoll.—Schering, U. S. Pat., 543214.

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CHAPTER XLIV

TOLUENE COMPOUNDS

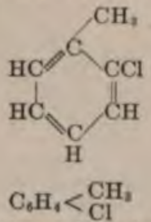
Toluene has the formula $C_6H_5CH_3$. It represents benzene in which one hydrogen is replaced by a methyl group. In this body, therefore, we have a combination of the ring and chain compounds, the methyl group possessing nearly all the reactions of the chain series of hydrocarbons, while the phenyl acts exactly as it did in benzene.

Toluene was first made by dry distillation of rosin by Pelletier and Walter in 1838. Deville (1841) obtained it by distillation of balsam of tolu, and from this circumstance Berzelius named it toluol.

It can be easily made by several reactions; chief among these are, (1) the *Friedel Crafts reaction*, in which benzene is treated with methyl chloride in the presence of aluminum chloride, and (2) by the *Fittig reaction* in which phenyl bromide is treated with methyl iodide in the presence of metallic sodium, this latter way being a modification of the Wuertz reaction mentioned on p. 574.

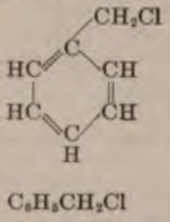
These two reactions are mentioned by name because affording means of the manufacture of any of the hydrocarbons of this series. Thus if ethyl chloride is substituted for the methyl chloride in the first reaction, or if ethyl iodide replaces methyl iodide in the second reaction, we would get ethyl benzene, $C_6H_5C_2H_5$.

Most commercial toluene, however, is obtained by the fractional distillation of coal-tar, and is a colorless or amber-colored liquid, of aromatic odor, suggestive of benzene. It has a specific gravity 0.870, and boils at 110°C., and is insoluble in water, but freely soluble in alcohol. In its chemical behavior it resembles benzene, on one hand, and methane, on the other, and in the same way forms two distinct lines of hydrocarbon derivatives. Thus, the replacing of one hydrogen of the benzene group by the addition of chlorine gives rise to the compound known as monochlor-toluene, and this body is produced when chlorine is passed into cold toluene. On the other hand, if boiling toluene is treated with chlorine, the halogen replaces one of the hydrogens of the methyl group, forming the body called benzyl chloride. The structural difference between these two bodies is best shown by the graphic formulas given below. These two compounds are mentioned not because of their importance in themselves, but by reason of the possible forms when the respective chlorines are replaced by hydroxyls, in the first case a phenol (cresol) being formed, whereas the benzyl chloride yields benzyl alcohol, which possesses all the characteristics of an ordinary fatty alcohol.



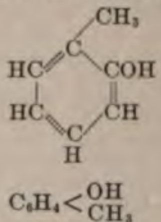
$C_6H_4<\substack{CH_3\\Cl}$

Orthomonochlor-toluene.



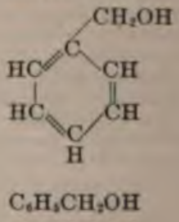
$C_6H_5CH_2Cl$

Benzylchloride.



$C_6H_4<\substack{OH\\CH_3}$

Orthocresol.



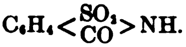
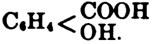
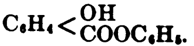
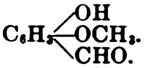
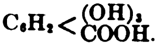
$C_6H_5CH_2OH$

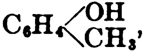
Benzyl alcohol.

Under appropriate treatment of boiling toluene with chlorine, there is also yielded benzotrichloride, $C_6H_5CCl_3$, and benzal chloride, $C_6H_5CHCl_2$.

The toluene derivatives of pharmaceutic interest are:

Cresol, U.S.P.	$C_6H_4<\substack{OH\\CH_3}$.
Creosol (Creosote, U.S.P. and creosote carbonate, U.S.P.)	$C_6H_3\substack{/CH_3\\-OCH_3\\\backslash OH}$.
Benzyl alcohol	$C_6H_5CH_2OH$.
Benzaldehyde, U.S.P. (Oil bitter almond, U.S.P.).	C_6H_5CHO.
Benzoic acid, U.S.P.	C_6H_5COOH.

Benzosulphinide, U.S.P.	 $C_6H_4<\begin{smallmatrix}SO_2\\CO\end{smallmatrix}>NH$.
Sodium benzosulphinide, U.S.P.	$NaC_7H_4O_3NS+2H_2O$
Salicylic acid, U.S.P.	 $C_6H_4<\begin{smallmatrix}COOH\\OH\end{smallmatrix}$.
(Methyl salicylate, U.S.P.)	
Phenyl salicylate	 $C_6H_4<\begin{smallmatrix}OH\\COOC_6H_5\end{smallmatrix}$.
Vanillin, U.S.P.	 $C_6H_3\begin{smallmatrix}OH\\OCH_3\\CHO\end{smallmatrix}$.
Gallic acid, U.S.P.	 $C_6H_2<\begin{smallmatrix}(OH)_3\\COOH\end{smallmatrix}$.
Tannic acid, U.S.P.	

The *cresols*,  $C_6H_4\begin{smallmatrix}OH\\CH_3\end{smallmatrix}$, are the monobasic phenols of toluene, and, like all di-derivatives of benzene, are known in the *ortho-*, *meta-*, and *para-* forms.

CRESOL—Cresol

A mixture of isomeric cresols [C_7H_8O or $C_6H_4.CH_3.OH$ = 108.06] obtained from coal tar. Preserve it in well-closed containers protected from light.

Summarized Description.

Colorless or yellowish to brown-yellow highly refractive liquid; turns darker with age; phenol-like odor; soluble in about 50 parts of water; miscible with alcohol, ether, benzene, petroleum benzin or glycerin; soluble in solutions of fixed alkaline hydroxides; sp. gr. 1.030 to 1.038; at least 90 per cent. distils between 195° and 205°C. For details see U.S.P., p. 126.

For *tests for identity* for *impurities:* Hydrocarbons (aqueous solution, 1 to 60, not more than slightly turbid) see U.S.P.

Manufacture.—In the manufacture of phenol from coal tar (see p. 688), the alkaline solution of the phenol fraction contains the cresols as well. When this alkaline solution is acidulated the cresols separate with the phenol and are separated by fractionation; they distilling between 195 and 205°C., while phenol distils at 188°.

Remarks.—As mentioned in the official definition, commercial cresol (or *cresylic acid*, as it is frequently called) is a mixture of the three cresols mentioned above. It has been accorded pharmacopœial recognition because a constituent of the new official, *compound solution of cresol.* It is sometimes used internally as an intestinal antiseptic.

Dose.—0.05 mil (1 minim).

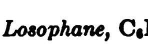
LIQUOR CRESOLIS COMPOSITUS—Compound Solution of Cresol

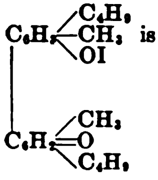
(Liq. Cresol. Co.)

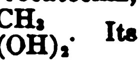
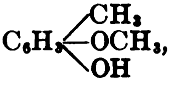
Condensed Recipe.

Heat 300 Gm. linseed oil on a water-bath to 70°C.; add to it 80 Gm. potassium hydroxide dissolved in 50 mils of water, likewise warmed to 70°C. After mixing add 30 mils of alcohol and warm until saponification is complete. Then add 500 Gm. cresol keeping mixture at 70° until a clear solution is produced. Lastly add enough water to make 1000 Gm. The potassium hydroxide may be replaced by the equivalent quantity of sodium hydroxide. For details see U.S.P., p. 240.

Remarks.—This is a 50 per cent. solution of cresol in an alkaline linseed oil soap solution, and is a product therapeutically similar to the popular alkaline solutions of coal-tar distillates, such as *creolin, lysol,* etc. Like these, it is used as an antiseptic wash or douche.

Losophane,  $C_6H(I_3)(OH)(CH_3)$, is cresol tri-iodide, contains 78.38 per cent. iodine, and is used as an iodoform substitute.

Europhene N.N.R,  $C_6H_2(C_4H_9)(CH_3)(OI)$—$C_6H_2(CH_3)(O)(C_4H_9)$ is di-isobutyl-cresol-iodide. A comparison of the formula just given with the name, shows how simple it is to express chemical structure in words. Europhen contains about 28 per cent. of iodine and is used like aristol.

Homopyrocatechin, so named because of its similarity to pyrocatechin, is the diatomic phenol of toluene. Its formula is  $C_6H_3(CH_3)(OH)_2$. Its methyl ester,  $C_6H_3(CH_3)(OCH_3)(OH)$, is known as *creosol,* and is of interest as a constituent of creosote.

CREOSOTUM—Creosote

Creosot.—Creasote

A mixture of phenols and phenol derivatives, chiefly guaiacol and creosol, obtained during the distillation of wood-tar. Preserve it in tightly stoppered, dark amber-colored bottles.

Summarized Description.

Colorless or yellowish, highly refractive inflammable oily liquid; penetrating smoky odor; burning caustic taste; should not become brown on exposure to light; slightly soluble in water; miscible with alcohol, ether, fixed or volatile oils; sp. gr. 1.073; distillation starts at 195°C., at least 80 per cent. distils between 200° and 220°C.

For details see U.S.P., p. 126.

For *tests for identity* and for *impurities:* Phenol and coal-tar creosote (does not coagulate collodion; creosotic layer separated from glycerinic solution by addition of water). Hydrocarbons and bases (alkaline solution not made turbid by addition of water). Cœrulignol, etc. (The top layer of a mixture of creosote with petroleum benzin and baryta water is neither blue nor muddy; the bottom layer is not red) see U.S.P.

Remarks.—This body was discovered by Reichenbach in 1830. The pharmacopœia defines it "as a mixture of phenols, . . . chiefly guaiacol and creosol."

Of these two bodies, guaiacol was described on p. 692, while the origin of creosol has just been given.

Creosote is obtained either from pyroligneous acid (p. 586) (the empyreumatic liquid obtained by the destructive distillation of oak wood) or from beechwood tar. As the last contains 25 per cent. creosote, while pyroligneous acid yields only 1 per cent., the former source of creosote is preferred.

The separation of creosote from the tar is a laborious process. The tar is distilled, the half coming over first is allowed to stand, when it separates into three layers. The lowest layer is the one containing the creosote.

The creosote layer is separated from the others, and saturated with sodium carbonate to neutralize acetic acid present, and is then distilled. This distillate yields two layers, the lower of which contains the creosote, and this is purified by treatment with phosphoric acid. After neutralizing the acid with ammonia and washing the oil with water, it is again distilled, the distillate then consisting of creosote and eupion; the latter is a body named by Reichenbach, and consists chiefly of pentane. The creosote is freed from eupion by treatment with solution of potassa, which saponifies it, while eupion floats on top and can be separated. The saponified creosote is then treated with sulphuric acid, and the free creosote rectified by repeated distillations.

Creosote is a straw- to amber-colored liquid, possessing a characteristic tarry color, and somewhat burning taste. It has a specific gravity of 1.078, is soluble in 150 parts of water (with formation of a cloudy liquid), and is soluble in alcohol, ether, and chloroform. As already noted, a large amount of the creosote in commerce is nothing but an impure form of carbolic acid, and special emphasis should be laid on the fact that such "coal-tar creosote" should never be used for internal administration; nor is there any excuse for ignorantly dispensing same, inasmuch as the pharmacopœia offers three distinct tests whereby the difference between creosote and carbolic acid may be recognized; the collodion test and the glycerin solubility test outlined about and the color produced with ferric chloride (pure violet blue with a solution of phenol; violet blue, then gray-green and lastly muddy-brown with a solution of creosote).

Creosote is a valuable antiseptic, its preservative action being due to the ease with which it coagulates albumin. This principle is employed in the so-called "smoking" of meats. The fresh meat is suspended in the vapors of burning wood, when the creosote of the vapors attack the albumin on the outer surface of the ham, forming an impermeable and antiseptic layer. To secure best results in smoking, beechwood should be used, though this is seldom the case.

Dose.—0.25 mil (4 minims).

Several preparations have been placed on the market under the name of "liquid smoke," and the like, and intended to be applied with a brush, consisting of various modifications of creosote or of crude pyroligneous acid, and this method of preserving meat is by no means as satisfactory as by the old process of smoking.

CREOSOTI CARBONAS—Creosote Carbonate

(Creosot. Carb.)

A mixture of the carbonates of various constituents of creosote, chiefly guaiacol and creosol.

Summarized Description.

Clear, colorless or yellowish, viscid liquid; on chilling, guaiacol carbonate crystals separate; insoluble in water; soluble in alcohol, petroleum benzin or fixed oils; miscible with chloroform or benzene; sp. gr. 1.145 to 1.170. For details see U.S.P., p. 125.

For *tests for identity*, for *impurities:* Creosote (alcoholic solution is neutral to litmus paper and turns yellow with ferric chloride). See U.S.P., p. 125.

Remarks.—This new official substance, called in trade, *creosotal*, is prepared by passing phosgene into an alkaline solution of creosote. The resulting oily product is then purified by washing with weak alkali and then with water. It is a yellowish, viscid liquid, that is claimed to be a non-irritant substitute for creosote and is used like the latter, as a pulmonic and intestinal antiseptic.

Dose.—1 gramme (15 grains).

Benzyl alcohol, $C_6H_5CH_2OH$, is the aromatic alcohol of toluene, and appears in the balsam of Peru and balsam of tolu, and can be made by treating benzyl chloride with moist silver oxide. It, like all primary alcohols, oxidizes first to aldehyde and then to acid, and in this way differs markedly from the cresols mentioned above, these being phenols, resembling more closely either the tertiary or the secondary alcohols.

Benzyl alcohol has but little pharmaceutic interest, and is mentioned merely because of its oxidation product, benzaldehyde.

BENZALDEHYDUM—Benzaldehyde

(Benzaldehyd.)

An aldehyde produced synthetically or obtained from oil of bitter almond and containing not less than 85 per cent. of C_7H_6O or $C_6H_5.CHO$(106.05). Preserve it in small, well-stoppered bottles, protected from light.

Summarized Description.

Colorless or yellowish, strongly refractive liquid; bitter-almond-like odor; burning aromatic taste; slightly soluble in water; miscible with alcohol, ether, fixed or volatile oils; sp. gr. 1.045. For details see U.S.P., p. 74.

For *tests for identity* for *impurities:* Hydrocyanic acid (ferrous sulphate, potassium hydroxide, hydrochloric acid test). Chlorinated products (copper wire, flame test). Nitrobenzene (should not be reduced by zinc and diluted sulphuric acid to aniline, which in turn would become violet on oxidation with potassium dichromate. See U.S.P., and also Part V of this book.

Remarks.—Benzaldehyde, C_6H_5CHO, can be made by the oxidation of the benzyl alcohol just mentioned, or by treatment of benzyl chloride with milk of lime. It occurs in nature as the chief constituent of oil of bitter almond. It is used in perfumery, and rarely employed medicinally.

Dose.—0.03 mil (½ minim).

OLEUM AMYGDALÆ AMARÆ—Oil of Bitter Almond

(Ol. Amygd. Amar.—Bitter Almond Oil)

A volatile oil obtained by maceration and distillation from the ripe kernels of *Prunus Amygdalus* Stokes var. *amara* DeCandolle (Fam. *Rosaceæ*), and from other kernels containing amygdalin. It yields not less than 85 per cent. of benzaldehyde [C_7H_6O] and not less than 2 per cent. nor more than 4 per cent. of hydrocyanic acid [HCN]. The botanical source from which it is derived must be stated on the label. Preserve it in small, well-stoppered, completely filled, amber-colored bottles protected from light and air. Oil showing crystals of benzoic acid must not be dispensed. This Oil is intended for medicinal use. It must not be used for flavoring foods.

Summarized Description.

Clear, colorless or yellow, strongly refractive liquid; characteristic odor and taste; slightly soluble in water; soluble in alcohol and ether, also in 2 volumes of 70 per cent. alcohol; sp. gr. 1.038 to 1.060; refractive index, 1.5428 to 1.5439; optically inactive or very slightly dextrorotatory. For details see U.S.P., p. 285.

For *tests for identity* and for *impurities:* Chlorinated products (copper wire, flame test). Nitrobenzene (should not be reduced by zinc and acetic acid to aniline, which in turn would give the isonitrite reaction).

For *assay* see U.S.P., p. 285 and also Part V of this book.

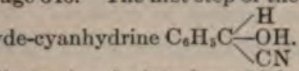
This is the volatile oil obtained from bitter almond by maceration with water and subsequent distillation.

Bitter almonds yield both fixed and volatile oil, and "sweet almond oil"—the expressed oil of almond—is obtained by expression from both kinds of almonds—bitter as well as sweet (p. 655).

Bitter almond in its dry form contains no volatile oil—no oil of bitter almond. To produce this, it is necessary to mash up the seed and add water, when a chemical reaction occurs between the amygdalin and emulsin present in the seed, one of the products of the reaction being oil of bitter almond.

Amygdalin belongs to the class of substances called glucosides (p. 640), which are bodies that on treatment with a diluted acid or ferment split into glucose and some other body. Emulsin is one of the unformed ferments explained on p. 844, hence a body that can break up amygdalin, as outlined above.

Feist has shown that the hydrolysis of amygdalin is not as simple as the reaction shown on page 640. The first step of the hydrolysis is the formation of one molecule of benzaldehyde-cyanhydrine



$C_6H_5C\begin{array}{l}\diagup H\\ -OH\\ \diagdown CN\end{array}$.

This when treated with steam in the process of distillation breaks into benzaldehyde and hydrocyanic acid.

When the amygdalin is split up by the emulsin, glucose, hydrocyanic acid, and oil of bitter almond are the three decomposition products, and only by the breaking up of the amygdalin is the oil developed. In the dry seed the amygdalin and emulsin rest quietly side by side, just as do the sodium bicarbonate and tartaric acid in dry effervescent salts, such as granular magnesium citrate. As soon as the water is added, just as the effervescent salts show energetic chemical action, even so, though marked only by the development of the bitter almond odor, does the emulsin react with the amygdalin.

In obtaining the bitter almond oil the fixed oil is separated by expression. The press cake is then mixed with water at 50°C. for about a day and then distilled. This results in the hydrolysis of the amygdalin under the influence of the ferment emulsin, as just explained. When using the ferment, great care must be exercised to prevent too great heat, as that causes decomposition of the ferment and its subsequent inactivity. This statement is worth bearing in mind, as there has arisen the erroneous impression that the reason why cold water is used in the wild-cherry preparations is to prevent the evaporation of the hydrocyanic acid. This is only partly true, the real object of avoiding hot water being to prevent decomposition of the ferment employed. From the volatile oil of bitter almond the hydrocyanic acid can be removed by treatment with ferrous sulphate and milk of lime and redistillation of the product with steam. This, however, is not done in the manufacture of the pharmaceutic oil, the pharmacopœia specifying that same shall contain 2 to 4 per cent. hydrocyanic acid, and this fact gives us a means of distinction between the synthetic benzaldehyde, which is free from hydrocyanic acid, and the natural oil of bitter almond. A very large quantity of such oil of bitter almond on the market represents synthetic benzaldehyde, and can be detected as mentioned above. Note in the pharmacopœial description given above that the crystals forming in bottles of the oil consist of benzoic acid.

Do not confound this synthetic oil of bitter almond—benzaldehyde—with the so-called artificial oil of bitter almond or *oil of mirbane.* This has nothing to do with the almond, being $C_6H_5NO_2$, nitrobenzene. Its unfortunate synonym is due to the fact that its odor suggests that of bitter almond.

Dose.—0.03 mil. (½ minim).

Amygdala Amara (U.S.P. VIII), or ***bitter almond,*** is the ripe seed of *Prunus Amygdalus* Stokes, var. *amara* De Candolle (Fam. *Rosaceæ*). It contains fixed oil, 45 per cent.; amygdalin, 2 to 3 per cent.; emulsin; asparagin and proteid (amandin).

The formation of the volatile oil, which does not exist in the dry seeds, but which is formed by the action of the emulsion on amygdalin, has been fully described just above. It acts as a sedative and is used largely as a flavor.

PRUNUS VIRGINIANA—Wild Cherry

(Prun. Virg.—Wild Black Cherry Bark)

The stem-bark of *Prunus serotina* Ehrhart (*Prunus virginiana* Miller) (Fam *Rosaceæ*), collected in autumn and carefully dried. Preserve Wild Cherry in tightly closed containers, protected from light.

Constituents.—Mandelonitrile glucoside (which is similar to, but not identical with amygdalin); an enzyme, similar to emulsin; volatile oil; two resins; benzoic, trimethyl-gallic and para-coumaric acids; sugar; and tannin.

Remarks.—The dry bark contains neither oil nor hydrocyanic acid, but, like bitter almond, these principles are produced when the bark is moistened, and, therefore, constitute the medicinal activity of the drug. A simple test for wild cherry is that it is the only official bark which, when chewed, gives the odor of hydrocyanic acid (or of bitter almond). The ferment emulsin is rendered inactive when treated with hot water, and no oil nor hydrocyanic acid will be developed in wild cherry when so heated; hence all official preparations of the bark, including the infusion, are made with cold solvents.

Medical Properties.—Tonic, mild sedative (for coughs).

Dose.—2 grammes (30 grains).

ACIDUM BENZOICUM—Benzoic Acid

(Acid. Benz.)

An organic acid obtained from benzoin, or prepared synthetically. It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 99.5 per cent. of $C_7H_6O_2$ or C_6H_5COOH (122.05). Preserve it in well-closed containers in a cool place protected from light.

Summarized Description.

Lustrous scales or friable needles; nearly odorless (the synthetic) or smelling like benzoin (the natural); pungent acid taste; somewhat volatile at moderately warm temperatures; volatilized by steam; soluble in about 275 parts of water and in about 1.8 parts of alcohol; also soluble in ether, chloroform, carbon disulphide, benzene, fixed and volatile oils; melts between 120° and 122°C. For details see U.S.P., p. 8.

For *tests for identity*, for *impurities:* Readily carbonizable matter (solution in sulphuric acid poured in water gives a precipitate of benzoic acid and a colorless fluid). Chlorine (modified silver nitrate test). Cinnamic Acid (no odor of bitter almond on oxidation with permanganate), and for *assay*, see U.S.P. p. 8 and also Part V of this book.

Remarks.—Benzoic acid represents the final oxidation product of benzyl alcohol, this yielding benzaldehyde, and it in turn yielding benzoic acid.

$$\underset{\text{Benzyl alcohol.}}{C_6H_5CH_2OH} \rightarrow \underset{\text{Benzaldehyde.}}{C_6H_5CHO} \rightarrow \underset{\text{Benzoic acid.}}{C_6H_5COOH.}$$

Benzoic acid was discovered by Vigniere in 1608 in benzoin, hence the name. Scheele in 1785 discovered it was a constituent of the urine, and Liebig and Woehler in 1832 proved its chemical composition. As mentioned above, benzoic acid is a normal constituent of benzoin, and is also an important constituent of balsams; balsams being oleoresins containing benzoic and cinnamic acids.

Benzoic acid can be made from benzene by converting same first into phenyl chloride, C_6H_5Cl, changing this to benzonitril, C_6H_5CN, and treating this with potassium hydroxide, when the potassium benzoate is formed.

As mentioned above, it is also made by the oxidation of either benzyl-alcohol or benzaldehyde. Commercial benzoic acid, however, is usually manufactured by one of the four following methods:

(*a*) *Sublimation of benzoin,* as described fully on p. 975.

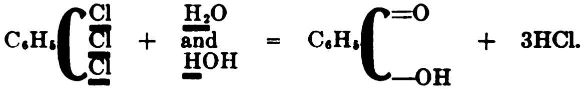
(*b*) *From Hippuric Acid.*—This body is a constituent of the urine of cattle, and is benzoyl glycocoll, $C_6H_5CONHCH_2COOH$.

On boiling this substance with hydrochloric acid it splits into glycocoll (amido-acetic acid), $\overset{\diagup NH_2}{CH_2}COOH$, and benzoic acid.

The benzoic acid thus produced is usually mixed with benzoin and resublimed, and when fresh, is an acceptable preparation. In older samples the origin can be readily detected by the odor of stale urine. The benzoic acid of this source was formerly used in considerable quantities under the name of *German benzoic acid*, but at the present time the process has been largely supplanted by a third method of manufacture.

(*c*) *From Toluene.*—A comparison of the formulas of toluene, $C_6H_5CH_3$, and of benzoic acid, C_6H_5COOH, will show that the difference between them is slight; benzoic acid has two atoms of oxygen more and two atoms of hydrogen less, and, therefore, it should be easily prepared by oxidation.

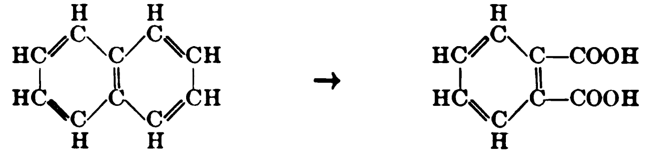
This, however, is not wholly the case, the reaction being rather indirect. Toluol is treated with chlorine, changing it, $C_6H_5CH_3$ into $C_6H_5CCl_3$, and this, when boiled with water, is converted into benzoic and hydrochloric acids, by the following reaction:



$$C_6H_5\left\{\begin{matrix}Cl\\ \underline{Cl}\\ \underline{Cl}\end{matrix}\right. + \begin{matrix}H_2\underline{O}\\ \text{and}\\ \underline{H}OH\end{matrix} = C_6H_5\left\{\begin{matrix}C=O\\ \\ -OH\end{matrix}\right. + 3HCl.$$

(*d*) *Process of Manufacture from Naphthalene.*—This body is $C_{10}H_8$, or, graphically, as expressed in Formula I below, and on oxidation with nitric acid, it yields phthalic acid, $C_6H_4(COOH)_2$, which is graphically expressed in Formula II.

FORMULA I. FORMULA II.

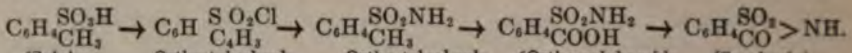


Phthalic acid, on treatment with calcium hydroxide, loses one CO_2 group, and is converted into benzoic acid, C_6H_5COOH, or rather into its calcium salt.

Benzoic acid is used as an antiseptic and employed medicinally chiefly in the form of metallic benzoates.

Dose.—500 milligrammes (8 grains).

Sulphobenzoic acid, $C_6H_4\Big\langle{SO_3H \atop COOH}$, made by treating benzoic acid with sulphuric acid, is mentioned because of its amido-derivative, *saccharin*, $C_6H_4{SO_2 \atop CO}\Big\rangle NH$, which was discovered by Remsen and Fahlberg in 1879. Its synthesis can best be expressed by successive products of the reaction:



$$C_6H_4\genfrac{}{}{0pt}{}{SO_3H}{CH_3} \rightarrow C_6H\genfrac{}{}{0pt}{}{SO_2Cl}{C_4H_3} \rightarrow C_6H_4\genfrac{}{}{0pt}{}{SO_2NH_2}{CH_3} \rightarrow C_6H_4\genfrac{}{}{0pt}{}{SO_2NH_2}{COOH} \rightarrow C_6H_4\genfrac{}{}{0pt}{}{SO_2}{CO}{>}NH.$$

(Sulpho-toluene). Ortho-toluol-sulphochloride. Ortho-toluol-sulphamide. (Ortho-sulphamide benzoic acid). (Saccharin).

Toluene, when treated with sulphur trioxide, yields sulphotoluene, $C_6H_4\langle\genfrac{}{}{0pt}{}{SO_3}{CH_3}H$. This yields successively the products given above, the end-product being saccharin, which is official as—

BENZOSULPHINIDUM—Benzosulphinide

(Benzosulphinid.—Saccharin—Glusidum)

The anhydride [$C_7H_5NSO_3$ or $C_6H_4SO_2.CONH$ = 183.12] of ortho-sulphamide-benzoic acid.

Summarized Description.

White crystals, or white crystalline powder; odorless or faintly aromatic; intensely sweet when diluted; soluble in about 290 parts of water and in about 25 parts of alcohol; also soluble in chloroform and ether and in some alkaline solutions; melts between 219° and 222°C.

For details, see U.S.P., p. 76.

For *tests for identity* and for *impurities:* carbonizable matter (sulphuric acid solution heated to 50°C., not more than brown).

Glucose or milk-sugar (does not reduce Fehling's solution).

Benzoic or salicylic acid (no precipitate nor violet color with ferric chloride).

Ammonium compounds (no ammonia odor on heating with a milk of magnesia). See U.S.P.

Remarks.—Saccharin is in the form of white powder, sparingly soluble in water, and possessing a taste that has been graphically described as being "so sweet that it is bitter" (being 300 times sweeter than sugar), and in order to obtain its full sweetening power it is necessary that it be diluted. Administered as a sweetener, it is usually combined with alkali, such as sodium bicarbonate, and the saccharin tablets intended for use by diabetic patients in place of sugar are combined with the required quantity of alkali before compression. The addition of alkali is in order to render them more soluble.

As noted in the summarized description just given, saccharin is only sparingly soluble in water. The sodium compound, on the other hand, is very soluble, although not so powerful an antiseptic.

Saccharin is by no means a harmless agent, and its indiscriminate use as a sweetener should be deprecated. For diabetic patients it is a boon, but, on the other hand, for sweetening foods in order to spare the cost of the sugar its use should be strongly condemned.

It is of interest to note that saccharin possesses valuable antiseptic properties, the researches of Miller showing that saccharin ranked in activity next to bichloride of mercury as an agent for destroying the bacteria of the mouth.

Professor Miller devised a saccharin mouth-wash containing saccharin, an astringent substance like krameria, blended with aromatics, and products similar to this are among the most popular of the modern mouth-wash preparations.

Dose.—200 milligrammes (3 grains).

SODII BENZOSULPHINIDUM—Sodium Benzosulphinide

(Sod. Benzosulphin.—Sodium-Saccharin—Soluble Saccharin)

The sodium salt [$NaC_7H_4O_3NS+2H_2O$ = 241.14] of benzosulphinide. Preserve it in well-closed containers.

Summarized Description.

Colorless, rhombic prisms or white crystalline powder; odorless or faintly aromatic, intensely sweet taste; soluble in about 1.2 parts of water and in about 40 parts of alcohol. For details see U.S.P., p. 383.

For *tests for identity* and for *impurities*, see benzosulphinide.

Remarks.—This new official substance is the soluble form of saccharin described above.

Dose.—200 milligrammes (3 grains).

ACIDUM SALICYLICUM—Salicylic Acid

(Acid. Salicyl.)

Orthohydroxybenzoic acid, existing naturally in combination in various plants, but generally prepared synthetically. It contains, when dried to constant weight in a dessiccator over sulphuric acid, not less than 99.3 per cent. of $C_7H_6O_3$ or $C_6H_4(OH)$-COOH (138.05). Preserve it in well-closed containers.

Summarized Description.

Fine prismatic needles or bulky crystalline powder; sweetish, then acrid taste; synthetic is white and odorless; natural is yellowish and smells like gaultheria; soluble in about 460 parts of water and in about 2.2 parts of alcohol; also soluble in chloroform, ether, benzene and oil of turpentine, melts between 156° and 159°. For details see U.S.P., p. 23.

For *tests for identity*, for *impurities:* Iron, phenol or coloring matter (alcoholic solution on evaporation gives a residue which is not more than slightly yellow or slightly pink). Organic impurities (does not color sulphuric acid more than faint brown). Hydrochloric acid (the silver nitrate test) and for *assay* see U.S.P., p. 23 and also Part V of this book.

This body is *ortho-oxybenzoic acid.* It was discovered and named by Piria in 1839 as an oxidation product of salicin. It occurs naturally in several of the volatile oils, notably that of wintergreen and sweet birch. The synthesis of salicylic acid has been accomplished in several ways. One is by fusing salicin with potassium hydroxide. It can also be made by treating orthocresol with potassa, but its commercial manufacture is by treatment of sodium carbolate with carbon dioxide, this being the celebrated *Kolbe's process.*

This can be best explained as the shoving of a molecule of CO_2 into a molecule of phenol. Phenol is C_6H_5OH, or it can be expressed as $C_6H_4\begin{matrix}-OH\\-H\end{matrix}$; treat this with CO_2, and we get salicylic acid, $C_6H_4<\begin{matrix}OH\\COOH\end{matrix}$.

It is interesting to note that in this case potassium carbolate cannot be used for the sodium carbolate. If the potassium carbolate is used, instead of getting ortho-oxybenzoic acid, we obtain the para-oxybenzoic acid.

Salicylic acid occurs in fine white needles or light crystalline powder, soluble in 460 parts of water and 2.2 parts of alcohol, melting at 156° to 159°C. It gives a very characteristic and delicate reaction with ferric chloride, the latter agent giving a distinct red tint in an aqueous solution of one part salicylic acid to 400,000 parts water, or, roughly speaking, 1 grain dissolved in 7 gallons of water will give distinct reaction with ferric chloride. More concentrated solutions of salicylic acid or salicylates give a deep purple precipitate with ferric chloride.

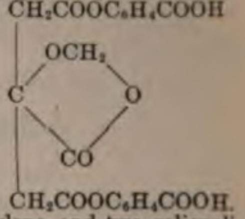
Salicylic acid is a valuable antipyretic, antirheumatic, and antiseptic.

Dose.—750 milligrammes (12 grains).

Several derivatives of salicylic acid are official: the salicylates of the metals, sodium, lithium, ammonium, and strontium; of the alkaloids, physostigmine and quinine; and the esters, methyl salicylate and phenyl salicylate.

Acetylsalicylic Acid (N.N.R.), or *aspirin*, $C_6H_4O(CH_3CO)COOH$, is salicylic acid in which the hydrogen of the hydroxyl group has been replaced by the acetyl group. It is made by heating salicylic acid with acetic anhydride. It occurs in colorless crystalline needles melting at 135°C. It is enormously popular as a substitute for salicylates and is given in doses of from 5 to 15 grams (0.3 to 1.0 gramme).

Novaspirin (N.N.R.), or *methylene-citryl-salicylic acid*,



represents the citric acid molecule to which one oxy-methylene and two salicyeli groups have been attached. Its use is similar to aspirin.

METHYLIS SALICYLAS—Methyl Salicylate

(**Methyl. Salicyl.**—Oleum Gaultheriæ, U.S.P. VIII—Oil of Wintergreen—Oleum Betulæ, U.S.P. VIII—Oil of Sweet Birch—Oil of Teaberry)

It contains not less than 98 per cent. of $CH_3C_7H_5O_3$(152.06). It is produced synthetically or is obtained by distillation from *Gaultheria procumbens* Linné (Fam. *Ericaceæ*) or from *Betula lenta* Linné (Fam. *Betulaceæ*). The label must indicate whether the methyl salicylate has been made synthetically or distilled from either of the above-mentioned plants. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, yellowish or reddish liquid; odor of gaultheria; sparingly soluble in water; miscible with alcohol and with glacial acetic acid; soluble in 6 volumes of 70 per cent. alcohol with but little cloudiness; sp. gr. 1.180 to 1.185 (synthetic) 1.172 to 1.182 (natural); boils between 218° and 221°C. For details see U.S.P., p. 272.

For *tests for identity*, for *impurities:* Other volatile oils or petroleum (dissolves in potassium hydroxide without leaving oil drops). Heavy metals (hydrogen sulphide test) and for *assay* see U.S.P., p. 273 and also Part V of this book.

Remarks.—The present pharmacopœia recognizes under the title *methylis salicylas*, the three commercial varieties of this chemical; the synthetic form and the two natural oils, that of wintergreen and of sweet birch. Synthetic methyl salicylate is made by treating methyl alcohol with salicylic acid in the presence of sulphuric acid, as shown by the following equation:

$$CH_3OH + HC_7H_5O_3 = CH_3C_7H_5O_3 + H_2O.$$

In this case, as in making all esters, the sulphuric acid acts as a dehydrating agent, removing the water formed during the reaction. While both oil of sweet birch and oil of wintergreen are harvested, the yield of the latter oil is so small, that most of the so-called "oil of wintergreen" is really obtained from birch. The differentiation between these two oils is a matter of considerable difficulty. In fact, no less an authority than Professor Kremers claims that it is practically impossible to decide chemically whether a given sample is from wintergreen or from birch. The present pharmacopœa cites as a distinction that oil of birch is optically inactive, while oil of gaultheria is slightly levogyrate.

As methyl salicylate can be made by combining methyl hydroxide and salicylic acid, so oil of wintergreen and oil of birch can be split up into these two constituents by the process of treating the oil with sodium hydroxide, when the methyl salicylate is decomposed by the following reaction:

$$CH_3C_7H_5O_3 + NaOH = CH_3OH + NaC_7H_5O_3.$$

This process of breaking down an ester is called *saponification*, because the formation of soap from a fixed oil—an ester of glycerin—is accomplished by a practically identical process. (See p. 665.)

The saponification of the oil of wintergreen under the influence of sodium hydroxide is applied commercially in the manufacture of the so-called natural salicylate of sodium and salicylic acid. The process is a simple one, the oil being warmed in a porcelain dish on a water-bath, and then treated with molecular proportions of a solution of soda, when the sodium salicylate separates out in a white mass. On adding water the sodium salicylate dissolves, the solution is then filtered, and sodium salicylate obtained from the solution by granulation through evaporation. In preparing sodium salicylate by this process it is important that there be a slight excess of acid, otherwise the finished product will have an ugly gray color. Scrupulous pains must be taken to avoid any contact with iron during the manufacture, for the slightest trace of iron will color the sodium salicylate from pink to red. From this sodium salicylate a natural salicylic acid can be isolated by treatment with the requisite quantities of sulphuric acid and crystallization of the separated salicylic acid from alcohol.

These three forms of methyl salicylate are used as antirheumatics, but the less irritating sodium salicylate is usually preferable.

Dose.—0.75 mil (12 minims).

PHENYLIS SALICYLAS—Phenyl Salicylate

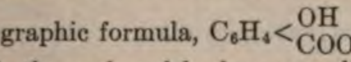
(Phenyl. Salicyl.—Salol)

The phenyl ester [$C_{13}H_{10}O_3$ or $C_6H_4(OH)COOC_6H_5$ 1:2 = 214.08] of salicylic acid. Preserve it in well-closed containers in a cool place.

Summarized Description.

White crystalline powder; aromatic odor; characteristic taste; soluble in about 6670 parts of water and in about 5 parts of alcohol; also soluble in chloroform, ether, benzene, fixed and volatile oils; melts between 41° and 43°C. For details see U.S.P., p. 318.

For *tests for identity* and for *impurities*: Free acids (litmus paper test). Uncombined phenol or salicylic acid (no violet color with ferric chloride). Sulphates and chlorides (usual tests) see U.S.P., p. 318 and also Part V of this book.

This graphic formula,  $C_6H_4<\begin{matrix}OH\\COOC_6H_5\end{matrix}$, shows that salol is salicylic acid with the carboxyl hydrogen replaced by the phenyl group (C_6H_5). It can also be written as phenyl salicylate, $C_6H_5C_7H_5O_3$.

Salol is an artificial ester obtained by the treatment of phenol with salicylic acid in the presence of phosgene, sulphuric acid not being indicated in this case, since its action would be too violent. The equation of manufacture is—

$$C_6H_5OH \quad + \quad HC_7H_5O_3 \quad = \quad C_6H_5C_7H_5O_3 \quad + \quad H_2O.$$

Like phenol, salol liquefies when triturated with menthol camphor and thymol.

Salol is a remedy of comparatively recent origin, and has been found admirable in rheumatic cases, it having a less irritating action than have the other salicylates.

Dose.—300 milligrammes (5 grains).

Salol is interesting because insoluble in acids, but freely soluble in alkalis. On account of this peculiarity it is used for a coating for enteric pills, such pills being desired to pass through the acid juices of the stomach undissolved, but intended to dissolve in the alkaline juices of the intestines (p. 311).

So successful has salol proved that a large number of derivatives from it are now found on the market.

Salophen is acetyl-para-amido-salol, $p\text{-}C_6H_4{<}\begin{smallmatrix}OCOC_6H_4OH\\ NHCOCH_3.\end{smallmatrix}$ The structure of this body can be best explained by the stages of its manufacture. Salol is converted into para-nitro-salol, $p\text{-}C_6H_4\begin{smallmatrix}\diagup OCO{-}C_6H_4OH\\ -NO_2.\end{smallmatrix}$ This, by reduction, gives para-amido-salol, $p\text{-}C_6H_4{<}\begin{smallmatrix}OCO{-}C_6H_4OH\\ NH_2\end{smallmatrix}$, and this, treated with acetic acid, yields salophen.

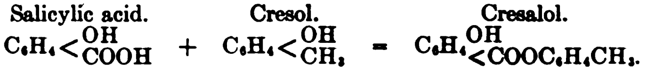
Salophen is used as a salol substitute in rheumatic and gastric troubles, it being considered safer than salol.

Saliphen, $C_6H_4\begin{smallmatrix}\diagup OC_2H_5\\ -NHC_7H_5O_2\end{smallmatrix}$.—This body is a salicyl-phenetidin, and is mentioned in passing merely to call attention to the confusing similarity of the names of these two substances.

Salicylamide, $C_6H_4{<}\begin{smallmatrix}CONH_2\\ OH\end{smallmatrix}$.—This is made by treating oil of wintergreen with ammonia gas, and is used as a salicylic acid substitute.

Cresalol, $C_6H_4{<}\begin{smallmatrix}OH\\ COOC_6H_4CH_3\end{smallmatrix}$.—Salol is salicylic acid combined with the phenol, C_6H_5OH. Cresalol is salicylic acid combined with cresol, $C_6H_4\begin{smallmatrix}\diagup CH_3\\ \diagdown OH.\end{smallmatrix}$

It is made by combining sodium salicylate and sodium cresylate in the presence of phosphorus oxychloride, $POCl_3$. The reaction can best be shown by the two compounds uncombined with sodium, viz.:



$$\underset{\text{Salicylic acid.}}{C_6H_4{<}\begin{smallmatrix}OH\\ COOH\end{smallmatrix}} + \underset{\text{Cresol.}}{C_6H_4{<}\begin{smallmatrix}OH\\ CH_3\end{smallmatrix}} = \underset{\text{Cresalol.}}{C_6H_4{<}\begin{smallmatrix}OH\\ COOC_6H_4CH_3.\end{smallmatrix}}$$

DIOXYBENZOIC ACIDS

We have already seen that salicylic acid is a mono-oxybenzoic acid, or a phenol in which one atom of hydrogen has been replaced by the carboxyl group. In the same way the dioxyphenols, by substitution of one atom of hydrogen with carboxyl, yield dioxybenzoic acids.

Thus, pyrocatechin, $o\text{-}C_6H_4(OH)_2$, yields protocatechuic acid, $C_6H_3\begin{smallmatrix}(OH)_2(3:4).\\ COOH(1)\end{smallmatrix}$

Resorcin, $m\text{-}C_6H_4(OH)_2$, yields resorcylic acid, $C_6H_3\begin{smallmatrix}(OH)_2(3:5).\\ COOH(1)\end{smallmatrix}$

Hydroquinine, $p\text{-}C_6H_4(OH)_2$, yields gentisinic acid, $C_6H_3\begin{smallmatrix}(OH)_2(2:5).\\ COOH(1).\end{smallmatrix}$

These acids are of little importance in pharmacy.

Gentisinic acid is a decomposition product of gentisin (p. 642), and protocatechuic acid is of interest only by reason of an important derivative of its aldehyde.

Protocatechuic aldehyde has the formula $C_6H_3\begin{smallmatrix}\diagup CHO\\ -OH\\ \diagdown OH\end{smallmatrix}$, and the methyl ether of this aldehyde is vanillin.

VANILLINUM—Vanillin

(Vanillin)

Methylprotocatechuic aldehyde [$C_8H_8O_3$ or $C_6H_3.OH.OCH_3.COH$ 4 : 3 : 1 = 152.06] occurring naturally in vanilla, or prepared synthetically. **Preserve it in well-closed containers, protected from light.**

Summarized Description.

Fine, white or faintly yellow, crystalline needles; soluble in about 100 parts of water and in alcohol, glycerin, chloroform or ether; optically inactive; melts between 80° and 82°C. For details see U.S.P., p. 485.

For *tests for identity* and for *impurities:* Acetanilid (does not give the isonitrile reaction) see U.S.P.

Remarks.—Vanillin is the odorous principle of the vanilla bean, which has long been popular as a flavoring agent. The extraction of vanillin from vanilla beans is a matter of comparatively little difficulty, but the small yields caused its commercial extraction to be at a cost almost prohibitive. The researches of Tiemann, however, proved the structural formula of the substance, and when this was known, the investigator found it a matter of no great difficulty to prepare vanillin from cheaper sources than from vanilla beans. The first vanillin made synthetically was made from coniferin found in the cambial juices of some species of pine. Vanillin from this source was prepared by Tiemann and Haarmann in their chemical factory at Holzminden, and soon became an article of commerce. A few years later, however, Tiemann discovered a simpler and more economic source of the production of vanillin in eugenol, a constituent of the oil of cloves, from which it is obtained by oxidation with potassium permanganate.

Vanillin occurs in the form of white crystals, melting at 81°C., freely soluble in alcohol, and much less so in water. It possesses a delightful odor of the vanilla beans, and is now very largely used instead of vanilla beans, both in flavoring extracts and particularly in perfumery.

Dose.—30 milligrammes (½ grain).

Vanilla (U.S.P. VIII; N.F. IV) is the cured, full grown, unripe fruit of *Vanilla planifolia* Andrews (Fam. *Orchidaceæ*). It contains vanillin, volatile oil, fixed oil, resin, sugar and mucilage. There is a great variation in quality of commerce vanilla beans, ranging from Mexican beans, the finest, to the Tahiti bean, the poorest—so poor that they should not be used. The poorer the quality, the more mucilage and less aroma the bean possesses. Vanilla is used almost entirely as a flavor.

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CHAPTER XLV

GALLIC AND TANNIC ACIDS

ASTRINGENT DRUGS

ACIDUM GALLICUM—Gallic Acid

(Acid. Gallic.)

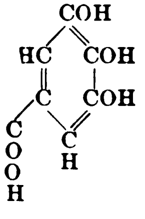
An organic acid [$C_7H_6O_5+H_2O$ or $C_6H_2(OH)_3.COOH$ 1:3:4:5$+H_2O=188.06$].

Summarized Description.

White or pale fawn-colored silky interlaced needles, or triclinic prisms; astringent, slightly acidulous taste, soluble in about 87 parts of water, in about 3.7 parts of alcohol and in about 70 parts of ether; almost insoluble in chloroform. For details see U.S.P., p. 11.

For *tests for identity* and for *impurities:* Tannic acid (is not precipitated by **gelatin** or by starch solutions) see U.S.P.

Remarks.—The graphic formula of gallic acid is—



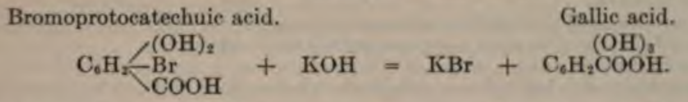
$C_6H_2(OH)_3COOH$, or, massed together, $HC_7H_5O_5$.

Such is gallic acid, which is benzene with three hydroxyls and one carboxyl replacing four hydrogen atoms.

While protocatechuic acid represents dioxybenzoic acid, it will be seen from the above formula that gallic acid is a *trioxybenzoic acid.*

Gallic acid was isolated from nutgall by Scheele in 1785, who gave it the name from the source of its supply.

Gallic acid can be made synthetically by fusing of bromoprotocatechuic acid with potassa, as shown in the following equation:



Bromoprotocatechuic acid. Gallic acid.

$$C_6H_2\begin{cases}(OH)_2\\ Br\\ COOH\end{cases} + KOH = KBr + \overset{(OH)_3}{C_6H_2}COOH.$$

It is usually obtained by macerating nutgalls with water long enough (several weeks) to hydrolyze the tannin into gallic acid. The cold acid aqueous liquid, in which but little gallic acid and much of the foreign matter dissolves, is expressed and thrown away. The press cake is then treated with boiling water, in which the gallic acid freely dissolves, and the hot infusion set aside to permit crystallization of the acid.

Gallic acid is a valuable astringent, of particular service as a harmless agent for stopping minor hemorrhages, such as nosebleed. In such case snuffing a small quantity of gallic acid up the nose usually staunches the flow of blood. It is given as an intestinal astringent, and is also used externally; for this purpose the official ointment of gallic acid is recommended.

Dose.—1 gramme (15 grains).

Bismuth subgallate is official, and has been described among the preparations of bismuth (p. 543).

ACIDUM TANNICUM—Tannic Acid

(**Acid. Tann.**—Gallotannic Acid—Tannin)

A tannin usually obtained from nutgalls. Preserve it in well-closed containers, in a cool place protected from light.

Summarized Description.

Yellowish-white or light brown amorphous powder or glistening scales or spongy masses; very faint characteristic odor; strongly astringent taste; soluble in about 1.25 parts of glycerin when gently warmed; quite soluble in water, alcohol and diluted alcohol; less so in dehydrated alcohol; almost insoluble in ether, chloroform, benzene and petroleum benzin. For details see U.S.P., p. 26.

For *tests for identity*, for *impurities:* Gum or dextrin (no turbidity on adding alcohol to an aqueous solution). Resinous matter (hot aqueous solution not turbid on cooling or on further dilution). See U.S.P. and also Part V of this book.

Remarks.—While for many years it was supposed that tannin was a definite chemical, di-gallic acid, $C_6H_3(OH)_3—COO—C_6H_2(OH)_2COOH$, the researches of Fischer and Freudenberg, Nierstein and Feist and Haun show that it is a mixture of di-gallic acid with other bodies, such as glucogallic acid, $CH_2OH—CHOH—\underbrace{CH—CHOH—CHOH—CH}_{O}O—CO—C_6H_2(OH)_2$ and leucotannin, $C_6H_2(OH)_3—O—C_6H_2—(OH)_2COOH$. For this reason the present pharmacopœia assigns no symbolic formula to tannin. Digallic acid, $C_{14}H_{10}O_9$, represents two molecules of gallic acid, $C_7H_6O_5$, minus one molecule of water.

The tannic acid of the pharmacopœia is but one of the very interesting series of compounds that we call the tannins (or tannoids). Most of these, instead of being pure digallic acid, are glucosides thereof. A very large number of plants yield various forms of tannins, and very few of these are identical.

Efforts have been made toward the classification of the tannins, and the first groups into which they are divided are according as to whether they form with iron salts a green black precipitate or a blue-black precipitate. The most modern classification of the tannins is that of Kunz Krause.

NON-GLUCOSIDAL TANNOIDS: Such as gallic acid; protocatechuic acid, digallic acid, etc.

GLUCOSIDAL TANNOIDS:

(a) *Glycotannoids.*

Protocatechuic acid derivatives, such as cinchotannic acid, caffetannic acid, etc.

Gallic acid derivatives, such as pomegranate root tannin.

(b) *Phloroglucin tannoids.*

Protocatechuic acid derivatives, such as quebracho tannic acid, catechutannic acid, kolatannin, etc.

Gallic acid derivatives, none yet known.

The protocatechuic acid derivatives mentioned above include those tannoids turning green black with ferric chloride; while the "gallic acid derivatives" turn blue black with ferric chloride.

It will be noticed in the pharmacopœial description that tannin is precipitated by gelatin (as discussed under Clarification, see p. 140) as a leathery substance, leather representing this very substance. Fresh animal hide consists of gelatin combined with a mass of animal fibers, and when this is macerated in a solution of tannin (generally from oak bark), it is converted into leather or the tannate of gelatin. The deep blue-black precipitate produced by the treatment of tannin with ferric chloride solution is the basis of most of our writing ink, which is made by treating nutgall infusion with iron salts and adding some gummy substance which will hold the precipitate in suspension.

Tannin is obtained by exposing powdered nutgalls to a damp atmosphere for several days, and then macerating with a small quantity of ether, and expressing the liquid, repeating the maceration and expression with ether containing one-sixteenth its bulk of water. The reason of this process of extraction is puzzling, since the tannin so obtained is practically insoluble in strong ether. Tannin can also be extracted from nutgall with a mixture of alcohol and ether, and in a patented process acetic ether is the solvent employed.

Tannic acid is one of the most valuable astringents, and is used both internally and externally. When used internally, it is given for diarrhea. For this purpose, however, it is usually advisable to administer a tannin-bearing drug, such as catechu or krameria.

Externally, it is used to staunch the flow of blood, and for gargles in sore throat and as an application for piles.

Dose.—500 milligrammes (8 grains).

The official preparations of tannin are glycerite of tannic acid, troches of tannic acid, and ointment of tannic acid.

DRUGS CONTAINING ASTRINGENT PRINCIPLES

Krameria (U.S.P. VIII; N.F. IV) or *rhatany* is the dried root of *Krameria triandra* Ruiz and Pavon (Peruvian Krameria), *Krameria Ixina* Linné (Savanilla Krameria,) or of *Krameria argentea* Martius (Para or Brazilian Krameria) (Fam. *Leguminosæ*). It contains kramerotannic acid, which consists of pure tannin, phlobaphene, and extract; krameric acid rhatanhin $HO—C_6H_4—CH_2CH(NHCH_3)COOH$: red coloring matter and starch. It is used as an astringent in 15-grain doses.

Geranium (U.S.P. VIII; N.F. IV) or *cranesbill* is the dried rhizome of *Geranium maculatum* Linné (Fam. *Geraniaceæ*). It contains tannin, gallic acid, mucilage and resin, and is used as an astringent in 15 grains.

Rubus (U.S.P. VIII; N.F. IV) or *blackberry root* is the dried bark of the rhizome of *Rubus villosus* Aiton, *Rubus nigrobaccus* Bailey, or of *Rubus cuneifolius* Pursh (Fam. *Rosaceæ*). It contains tannin, *villosin* (bitter glucoside), etc., and is used as an astringent in 15-grain doses.

Hæmatoxylon (U.S.P. VIII; N.F. IV) or *logwood* is the heart-wood of *Hæmatoxylon campechianum* Linné (Fam. *Leguminosæ*), that has not undergone fermentation. It contains tannin and *hematoxylin*, a neutral principle having the formula $C_{16}H_{14}O_6$, and giving the wood its color.

The "heart wood" means the heavier older wood found in the interior of a trunk. Its technical name is the "duramen," while the lighter, younger, outer wood is called the "alburnum." The hematoxylin mentioned above has chemical value as an indicator in volumetric analysis (p. 881).

Chief use of logwood is in dyeing, a decoction of the wood mixed with copperas coloring fabrics a deep black. For dyeing purposes, however, the wood is generally submitted to a fermentation process, when it assumes a green, metallic lustre. Such wood should not be used in medicine. Hematoxylon is used as an astringent usually in the form of the extract (p. 281).

Hamamelidis Cortex (U.S.P. VIII) or *witch hazel bark* is the bark and twigs of *Hamamelis virginiana* Linné (Fam. *Hamamelidaceæ*.) It contains tannin, bitter principle, chlorophyll and trace of volatile oil. It is an astringent of little value.

Dose.—30 grains.

Hamamelidis Folia (U.S.P. VIII; N.F. IV), or *witch hazel leaves*, are the dried leaves of *Hamamelis virginiana* Linné (Fam. *Hamamelidaceæ*), collected in autumn, before the flowering of the plants. The drug contains tannin and a trace of volatile oil and is used as an astringent, in 30-grain doses.

Quercus (U.S.P. VIII; N.F. IV), or *white oak bark*, is the dried bark of the trunks and branches of *Quercus alba* Linné (Fam. *Fagaceæ*) deprived of the periderm, or the outer corky layer of the bark. It contains tannin (quercitannic acid) oak red and pectin and is used as an astringent in 15-grain doses.

ROSA GALLICA—Red Rose

(Rosa Gall.)

The dried petals of *Rosa gallica* Linné (Fam. *Rosaceæ*), collected just before the expansion of the flower. Preserve Red Rose in tightly closed containers, protected from the light.

Constituents.—Tannin, gallic acid, trace of volatile oil, quercetin, color, etc.

Medical Properties.—Astringent tonic. *Rose honey*, U.S.P. (p. 204) was formerly highly esteemed as a wash for sore mouth. It is made from the official fluidextract (p. 245).

Rosa Centifolia (U.S.P. 1890) or *pale rose* contains a trace of tannin, and was used chiefly as a flavor. Bear in mind that while the official *stronger rose water* (p. 177) is made from these two roses, *oil of rose* comes from a different species of rose. (See p. 742.)

GALLA—Nutgall

(Gall.—Aleppo Galls—Smyrna Galls)

Excrescences on the young twigs of *Quercus infectoria* Olivier and other allied species of *Quercus* (Fam. *Fagaceæ*), induced by the punctures on the leaf-buds and by the deposited ova of *Cynips tinctoria* Hartig (Order *Hymenopteræ*). Not more than 5 per cent. of Galls float in water.

Constituents.—Tannin, 50 per cent. (a glucosidal form that hydrolyzes to glucose and digallic acid); gallic acid, 3 per cent.; pectose; a ferment (pectase), etc.

Remarks.—The above official definition ("excrescences on the young twigs of *Quercus infectoria*") should be analyzed if it is to be clearly understood. Excrescence means, literally, "an outward growth." In medicine, a boil, a mole, and a wart are, alike, excrescences, likewise, to a certain extent, the swellings caused by insect-bites, all such "outward growths" being the result of abnormal development of tissue caused by some irritation. So, in plainer English, we may say that nutgall is a swelling on *Quercus infectoria*, a swelling "induced by the punctures and by the deposited ova of *Cynips tinctoria*." To explain that part of the definition just quoted is easy. It has just been said that when an insect bites us, an "excrescence" is formed on the injured part. Likewise, official nutgall, the excrescence on a special variety of oak, is caused by the bite (puncture) of a special insect—*Cynips tinctoria*. This insect not only stings the oak, but also deposits in the puncture its eggs (*ova*, plural for *ovum*, an egg), and these are the foreign bodies that increase the irritation.

To make a résumé, the insect, *Cynips tinctoria*, with that unerring instinct given by Providence, chooses the tissue of an oak tree as the best place in which its young may be hatched, and, accordingly, pierces the younger branches and deposits its eggs in the hole.

The stung branch swells just as does a stung arm, and still more so, by reason of the irritating particles (the eggs) contained in the wound. So the swelling continues, until a round knob, about the size of a cherry, is formed—a morbid growth not unlike a wen or a tumor on human beings. While the excrescence, the nutgall, is growing, the insect eggs are undergoing that process of development called hatching, and when the nutgall assumes its full size, the eggs will have hatched and the young and hungry grubs enter into their curious world. All insects have two stages of existence, as seen, for instance, in the caterpillar, the larval stage, and the butterfly, the most highly developed stage of the same animal. In their larval state insects are destitute of wings, and in just such condition is *Cynips tinctoria* as it emerges from its egg within the nutgall. To its voracious appetite the soft tissue of the nutgall is exactly suited, and within this dark home it lives its larval life, and only after it has undergone the second transformation and becomes an insect does it desire to see the outer world. Then it bores its way through the walls of its prison cell, entering the living world about six months after the egg was laid.

As a matter of fact, nutgall should be collected before the insect has escaped, hence the gall should not be punctured, and on slicing should show a cavity containing remnants of the insect.

As already mentioned (p. 715), nutgall is the source of both official tannin and of gallic acid.

Medical Properties.—Valuable astringent. The official ointment (p. 332) is largely used for hemorrhoids.

Dose.—500 milligrammes (8 grains).

GAMBIR—Gambir

(Pale Catechu)

A dried extract prepared from decoctions of the leaves and twigs of *Ourouparia Gambir* (Hunter) Baillon (Fam. *Rubiaceæ*).

Constituents.—Catechu-tannic acid; catechin, quercetin, etc.

Remarks.—This drug replaces the formerly official catechu. It occurs in pale brownish-gray or light brown cubes, quite different in appearance from the dark brown catechu. It is used extensively as a dye-stuff, coloring black when combined with iron salts.

Medical Properties.—Astringent. Administered in diarrhea mixtures as the compound tincture (p. 227), and for throat troubles as the lozenges of The National Formulary (p. 322).

Dose.—1 gramme (15 grains).

Catechu, the extract of the wood of *Acacia catechu*, was official until the last revision, when it was replaced by gambir, with which it is identical as far as constituents and medical properties are concerned.

KINO—Kino

The spontaneously dried juice of *Pterocarpus Marsupium* Roxburgh (Fam. *Leguminosæ*).

Constituents.—Kinotannic acid; kinoic acid, kinoin, $C_{14}H_{12}C_6$; kino red, $C_{28}H_{22}C_{11}$, etc.

Remarks.—The only point worth noting regarding kino is the fact, already mentioned (p. 228), that kino contains an enzyme which causes the tincture to gelatinize, unless the official recipe is strictly followed.

Medical Properties.—Astringent. Administered in diarrhea mixtures as tincture (p. 228).

Dose.—500 milligrammes (8 grains).

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CHAPTER XLVI

AROMATIC HYDROCARBONS CONTAINING EIGHT, NINE, AND TEN CARBON ATOMS

THE hydrocarbons of the series C_nH_{2n-6}, containing eight carbon atoms, have the empiric formula,

$$\begin{array}{l} C_8H_{10} \\ C_n \;\; = C_8 \\ H_{2n-6} = H_{2\times8} = 16. \quad 16 - 6 = 10. \quad \text{Hence } H_{10} \end{array}$$

This formula includes the three forms of dimethyl-benzene, $C_6H_4(CH_3)_2$, that is, ortho-, meta-, and para-xylenes, and also ethyl benzene,

$C_6H_5C_2H_5$. From the three xylenes are derived the three forms of *phthalic acid*, $C_6H_4(COOH)_2$,which are mentioned in passing because the anhydride of the ortho acid in condensation with phenol yields *phenolphthalein*.

PHENOLPHTHALEINUM—Phenolphthalein

(Phenolphthal.)

A dibasic phenol derivative (dihydroxyphthalophenone) [$C_{20}H_{14}O_4$ or $(C_6H_4OH)_2$-$CO.C_6H_4CO$ = 318.11].

Summarized Description.

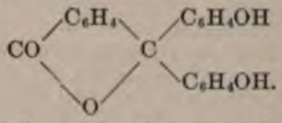
White or faintly yellowish-white crystalline powder; soluble in about 10 parts of alcohol and in about 50 parts of ether; almost insoluble in water; melts at not less than 253°C.; dissolves in solutions of alkaline hydroxides and carbonates to a red fluid; such solutions are decolorized by reduction or by addition of acids. For details, see U.S.P., p. 317.

For *tests for identity* and for *impurities* (Resinous substances (alcoholic solution is colorless).

Fluorene (completely soluble in a diluted solution of sodium hydroxide).

Heavy metals and arsenic (usual tests) see U.S.P., p. 318 and also Part V of this book.

Remarks.—This new official chemical has the structural formula:



Study will show that this is made of a part of one molecule of phthalic acid anhydride, $C_6H_4{<}^{CO}_{CO}{>}O$, and two molecules of phenol. It is made by heating these two substances with concentrated sulphuric acid.

Medical Properties.—Phenolphthalein has, of late years, become a highly popular purgative. It is the main constituent of such proprietaries as *probilin* and *phenolax*.

Dose.—150 milligrammes (2½ grains).

As a derivative of ethyl benzene might be cited *epinephrin*, $C_6H_3(OH)_2CHOH$-CH_2NHCH_3, obtained from the suprarenal glands (p. 851), and frequently prescribed under the trade names, *adrenalin*, *adrin*, *adnephrin*, etc.

Para-hydroxy-ethyl-phenylamine, $C_6H_4(OH)CH_2CH_2NH_2$, has been shown to be an active constituent of ergot (p. 837).

Among the hydrocarbons of this series containing nine carbon atoms are the three trimethyl benzenes, $C_6H_3(CH_3)_3$, of which the most important is the symmetric form, *mesitylene;* the three methyl-ethyl benzenes, $C_6H_4{<}^{CH_3}_{C_2H_5}$; and the two propyl benzenes, $C_6H_5C_3H_7$, of which the most important is the isopropyl form, *cumene*, $C_6H_5{-}CH{<}^{CH_3}_{CH_3}$.

Of far greater importance in pharmacy are the unsaturated hydrocarbons of this series, *allyl benzene*, $C_6H_5CH=CH-CH_3$, and *iso-allyl-benzene*, $C_6H_5CH_2CH=CH_2$. Neither of these bodies in themselves are of pharmaceutic interest, but each furnishes a long line of derivatives, many of which are constituents of volatile oils. Thus the alcohol of allyl-benzene is *cinnamic alcohol*, $C_6H_5CH=CHCH_2OH$, and this on oxidation yields *cinnamic aldehyde*, $C_6H_5CH=CHCHO$, and *cinnamic acid*, $C_6H_5CH=CHCOOH$.

The following derivatives of allyl benzene and iso-allyl-benzene are of pharmaceutic importance:

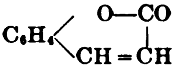
Cinnamic alcohol.
Cinnamic aldehyde.
Cinnamic acid.
Coumaric acid.
Coumarin.
Anethol.
Eugenol, U.S.P.
Safrol, U.S.P.
Apiol.

Cinnaldehydum (U.S.P., VIII) or *cinnamic aldehyde* is the aldehyde obtained from oil of cinnamon (p. 745). It can also be made synthetically as suggested above. Like oil of cinnamon, it is used as a carminative. Dose, 1 minim.

Both cinnamic aldehyde and cinnamic acid are found in nature elsewhere than in oil of cinnamon; that class of drugs called *balsams* being oleoresins containing benzoic and cinnamic acids, and usually some traces of the corresponding aldehydes.

Cinnamic acid is a crystalline solid of agreeable aromatic odor, and can be converted into oxycinnamic acid (*coumaric acid*), $C_6H_4{<}\begin{matrix}OH\\CH = CHCOOH\end{matrix}$. When coumaric acid is treated with acetic acid anhydride a molecule of water separates, with the formation of coumarin.

Coumarin (N.F.) is the anhydride of ortho-oxycinnamic acid. Its graphic formula is



$$C_6H_4{<}\begin{matrix}O-CO\\ \vert \\ CH=CH\end{matrix}$$

Coumarin was so named because first obtained from the Tonka bean, the fruit of *Dipteryx odorata* (formerly called *Coumarouna odorata*).

The synthesis of coumarin from coumaric acid was accomplished by Tiemann in 1877, and at present almost all the coumarin in commerce is made artificially.

Coumarin is also found in the aromatic herbs, such as deer's tongue (*Liatris odorissima*) and mellilot (*Mellilotus alba*). There are also traces in the ordinary grasses, in which it becomes prominent on drying; producing the odor of new-mown hay.

Coumarin occurs in white crystals, melting at 67°C., soluble in 14 parts of alcohol, and sparingly soluble in water. It is used for flavoring the cheaper grade of vanilla extracts.

Among other derivatives of allyl-benzene we find: *Ferulaic acid* (methyl-oxycinnamic acid), $C_6H_3{<}\begin{matrix}OH\\OCH_3\\CH = CHCOOH\end{matrix}$, the chief constituent of the resin of asafetida (p. 777).

Anethol (para-propenyl-anisol), formula, $C_6H_4{<}\begin{matrix}OCH_3\\CH = CHCH_3\end{matrix}$.

This body is the methyl ether of the phenol of allyl-benzene, $C_6H_4{<}\begin{matrix}OH\\CH=CH-CH_3\end{matrix}$. and is the chief constituent of the oils of anise, star anise, and fennel. It is a crystalline solid, melting at 21°C.

Two derivatives of iso-allyl-benzene ($C_6H_5CH_2CH=CH_2$) are worthy of notice.

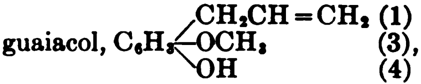
EUGENOL—Eugenol

An unsaturated, aromatic phenol [$C_{10}H_{12}O_2$ or $C_6H_3.C_3H_5.OCH_3.OH$ 1:3:4 = 164.10] obtained from oil of clove and from other sources. Preserve it in well-closed containers, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow strongly refractive, thin liquid; aromatic odor of cloves; pungent, spicy taste; darkens and becomes thicker on exposure to air; sp. gr. 1.064 to 1.070; miscible with alcohol; soluble in 2 parts of 70 per cent. alcohol; boils between 250° and 255°C.; optically inactive. For details see U.S.P., p. 141.

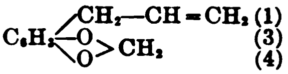
For *tests for identity* and for *impurities:* Phenol (alkaline solution gives gray-green, not a violet color with ferric chloride), see U.S.P. p. 141.

Remarks.—Eugenol is allyl guaiacol,  $C_6H_3\begin{cases}CH_2CH=CH_2 & (1)\\ OCH_3 & (3)\\ OH & (4)\end{cases}$, or the methyl ether of the divalent phenol from iso-allyl-benzene, $C_6H_3\begin{cases}CH_2CH=CH_2\\ OH\\ OH\end{cases}$, and is the chief constituent of the oil of cloves. It is an aromatic oily liquid, boiling at about 250°C.

Its conversion into vanillin has been already described (p. 713). Its medical properties are similar to oil of cloves, from which it is derived.

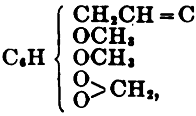
Dose.—0.2 mil (3 minims).

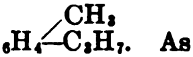
Safrolum (U.S.P. VIII), or *safrol*, is allyl pyrocatechin-methylene-ether,



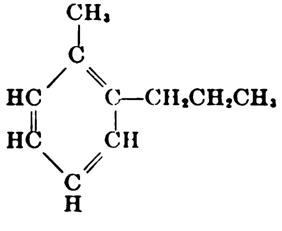
$$C_6H_3\begin{cases}CH_2—CH=CH_2 & (1)\\ \left.\begin{matrix}O\\ O\end{matrix}\right>CH_2 & \begin{matrix}(3)\\ (4)\end{matrix}\end{cases}$$

and represents eugenol, with its methyl group replaced by the methylene group $\left(\begin{matrix}—O\\ —O\end{matrix}>CH_2\right)$. It is the chief constituent of oil of sassafras, and is a crystalline solid, melting at 8.5°C. and boiling at 233°C. Its medical properties are similar to oil of sassafras, after which it is named.

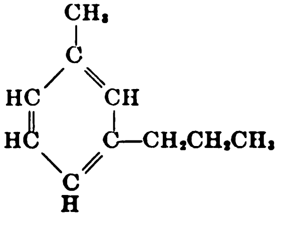
Apiol,  $C_6H\begin{cases}CH_2CH=CH_2\\ OCH_3\\ OCH_3\\ \begin{matrix}O\\ O\end{matrix}>CH_2,\end{cases}$ is safrol, with two hydrogen atoms of its benzene nucleus replaced by (OCH_3) groups. It is a constituent of parsley fruit, and is a crystalline solid, melting at 30°C. Commercial apiol, highly esteemed by French physicians as an emmenagogue, is said to be the oleoresin of parsley fruit. This oleoresin is now official (see p. 254), as well as the drug, from which it is derived (p. 752).

Several hydrocarbons having the formula $C_{10}H_{14}$ are known. The simplest of these are the methyl-propyl-benzenes,  $C_6H_4\begin{cases}CH_3\\ C_3H_7\end{cases}$. As all bi-derivatives of benzene are known in three modifications, ortho-, meta-, and para- (see p. 701), so we have ortho-, meta-, and para-methyl-propyl benzene, in which the propyl group is normal, viz.:

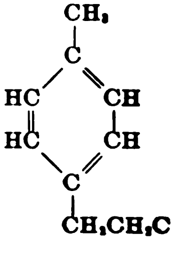
Ortho-



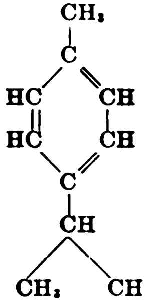
Meta-



Para-



More important than these, however, is the para-methyl-isopropylbenzene, or *cymene:*



This hydrocarbon, thus named because first found in oil of cumin (*Cuminum cyminum*), is made synthetically by treating para-brom-isopropyl-benzene with methyl iodide in the presence of metallic sodium.

The graphic formula of cymene, given above, is proved correct by the synthesis just mentioned, and also by its behavior under various oxidizing agents.

Under certain conditions of oxidation it can be changed to para-toluic acid, $C_6H_4\begin{matrix}CH_3\\ COOH\end{matrix}$; to terephthalic acid, $C_6H_4(COOH)_2$, or to cuminic acid, $C_6H_4\begin{matrix}COOH & (1)\\ CH(CH_3)_2 & (4).\end{matrix}$

It will be noted that in the first-named acid the propyl group is oxidized to the carboxyl group; in the third-named acid it is the methyl group that is converted into the carboxyl, the isopropyl group remaining; while in the second acid both methyl and propyl groups are changed to carboxyl groups. Since all three acids have the groups attached to the benzene nucleus in the para-position, that must be the position of the methyl and propyl groups in the cymene.

Cymene is of little practical importance in pharmacy, but it is of interest as a constituent of several volatile oils, notably, the oils from the various species of thyme.

The following cymene derivatives or analogues are of pharmaceutic importance:

Thymol, U.S.P.
Thymol iodide, U.S.P.
Carvacrol.
Carvone.

THYMOL—Thymol

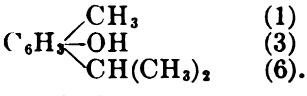
A phenol [$C_{10}H_{14}O$ or $C_6H_3(CH_3)(OH)(C_3H_7)$ 1:3:4 = 150.11] occurring in the volatile oil of *Thymus vulgaris* Linné (Fam. *Labiatæ*), and in some other volatile oils. Preserve it in well-closed containers.

Summarized Description.

Large, colorless, translucent, rhombic prisms; aromatic thyme-like odor; pungent aromatic taste; slightly caustic to the lips; soluble in about 1010 parts of water and in about 0.8 part of alcohol; also soluble in chloroform, ether, olive oil, glacial acetic acid, fixed and volatile oils; when solid, heavier than water, when fused lighter than water; melts between 48° and 51°C.; liquefies when triturated with camphor or menthol. For details see U.S.P., p. 442.

For *tests for identity*, for *impurities:* Phenol (alcoholic solution not colored violet by ferric chloride) see U.S.P.

Remarks.—Thymol is iso-propyl-meta-cresol:



$$C_6H_3\begin{matrix}CH_3 & (1)\\ OH & (3)\\ CH(CH_3)_2 & (6).\end{matrix}$$

It is an alcohol closely allied to cymene.

It occurs in several volatile oils; one of the most abundant sources being oil of horsemint. Thymol is obtained by saponifying oil of horsemint or oil of thyme, or a specific fraction of the same, with sodium hydroxide. The thymol sodium compound dissolves in the aqueous layer, which is separated from the oily portion, and the thymol set free by treating with hydrochloric acid.

It is also made in the manner similar to the manufacture of menthol, that is, by submitting the oil to a freezing mixture and separating the stearopten (thymol) from the eleopten (p. 729) by means of a centrifugal apparatus. Another method of obtaining thymol is by the fractional distillation of the oils mentioned above. Of these three processes, the chemical treatment with sodium hydroxide is the one generally employed. Thymol has also been made synthetically from cumin aldehyde.

Thymol affords an interesting illustration of crystallization by means of a nucleus. When obtained by the several methods just mentioned it is in the form of the thick liquid, and it is only when a crystal of thymol is introduced that the mass crystallizes. Thymol, when rubbed with some solid substance, such as chloral hydrate, menthol, and camphor, forms a thick liquid. A characteristic test for thymol is the blue-green color produced when a crystal of it is dissolved in glacial acetic acid and treated first with sulphuric acid, then with nitric acid.

Medical Properties.—An antiseptic, now largely used in the treatment of hookworm. When used for the latter purpose, purgative oils must not be given during the administration of the thymol, since oils hasten its absorption to such a degree, that toxic symptoms result.

Dose.—As antiseptic, 125 milligrammes (2 grains), as anthelmintic, 1 gramme (15 grains) per day.

THYMOLIS IODIDUM—Thymol Iodide

(Thymol. Iod.)

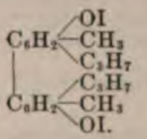
Chiefly, dithymol-di-iodide [$C_{20}H_{24}O_2I_2$ or $(C_6H_2.CH_3.C_3H_7.OI)_2 = 550.03$]. It contains, when dried to constant weight in a desiccator over sulphuric acid, not less than 43 per cent. of iodine (I = 126.92). Preserve it in well-closed containers, protected from light.

Summarized Description.

Reddish-brown or reddish-yellow bulky powder; slight aromatic odor; insoluble in water or glycerin; slightly soluble in alcohol; quite soluble in chloroform, ether, collodion, fixed or volatile oils; not soluble in sodium hydroxide solution; not more than 1.5 per cent. of ash. For details see U.S.P., p. 442.

For *tests for identity*, for *impurities* (halogens, alkalies, free iodine) and for *assay* see U.S.P., p. 443 and also Part V of this book.

Remarks.—This is the popular *aristol*, or dithymol di-iodide:

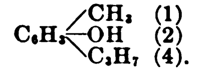


It is made by adding solution of 6 grammes of iodine, 9 grammes of potassium iodide, in 10 grammes of water, to a solution consisting of 5 grammes of thymol in 10 grammes of 13 per cent. sodium hydroxide solution. On mixing, aristol separates out in the form of a brown powder.

Aristol is a valuable iodoform substitute, containing the iodine in an easily assimilable form. From the standpoint of the iodine strength, however, it is inferior to both iodoform and iodol, for, as indicated by the formula, $C_{20}H_{24}O_2I_2$, it contains 46 per cent. of iodine (being $^{252}/_{550}$ iodine). The pharmacopœial requirement is that it should contain 43 per cent. of iodine and should yield not more than 1.5 per cent. of ash.

While the popularity of aristol is largely due to the persistent advertising of the firm who hold the monopoly of manufacture, it is a very valuable antiseptic, possessing over the iodoform the great advantage of having an agreeable odor. Some care should be bestowed on the keeping of aristol, as it is found that it decomposes when subjected to strong light.

Carvacrol.—An isomeric alcohol of thymol is carvacrol, iso-propyl-ortho-cresol,

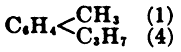


$$C_6H_3\begin{cases} CH_3 & (1)\\ OH & (2)\\ C_3H_7 & (4).\end{cases}$$

A comparison of this formula with that of thymol, given above, shows that the only difference is that in thymol the propyl group is attached to carbon atom number 6 of the benzene nucleus, while in carvacrol it is attached to carbon atom number 4. In both substances the propyl group is of the "iso" variety.

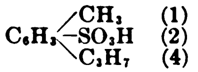
Carvacrol has been made synthetically from cymene by converting the latter (Formula I) into its sulphonic acid derivative (Formula II), and on replacing the acid group by a hydroxyl group, carvacrol (Formula III) is obtained.

Formula I.



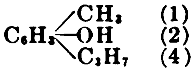
$$C_6H_4\begin{cases} CH_3 & (1)\\ C_3H_7 & (4)\end{cases}$$

Formula II.



$$C_6H_3\begin{cases} CH_3 & (1)\\ SO_3H & (2)\\ C_3H_7 & (4)\end{cases}$$

Formula III.

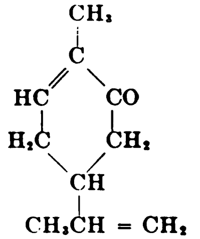


$$C_6H_3\begin{cases} CH_3 & (1)\\ OH & (2)\\ C_3H_7 & (4)\end{cases}$$

This body—a colorless, thick, acrid oil—is of little importance in pharmacy, save as a constituent of some volatile oils, notably oil of origanum.

It was first prepared by heating carvone with glacial phosphoric acid, and because so obtained, and by reason of its acridity, it was called carvacrol.

Carvone.—



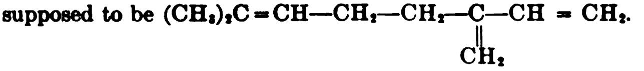
This body is a ketone, and is isomeric with carvacrol.

There are two forms of carvone, having the same graphic formula, but differing in that one deviates a ray of polarized light to the right, while the other turns it to the left. Dextrogyre carvone is the flavoring constituent of oil of caraway, *Carum carvi*, whence the name—carvone—is derived; while the levogyre form is a liquid of entirely different odor; that of oil of spearmint, of which it is the important constituent.

TERPENES

The terpenes are a series of hydrocarbons having the formula $C_{10}H_{16}$. While about twenty of these terpenes have been described, a much larger number is possible.

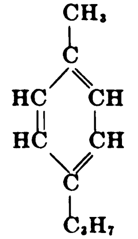
Thus we can imagine a series of chain compounds having the formula, $C_{10}H_{16}$, and among those which are known we find *anhydrogeraniol*, the formula of which is supposed to be



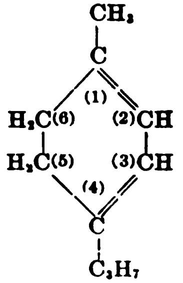
$$(CH_3)_2C=CH—CH_2—CH_2—\underset{\underset{CH_2}{\|}}{C}—CH=CH_2.$$

Again, we can have—what is generally the case—a body, $C_{10}H_{16}$, representing cymene, with one of its ethylene bonds loosened and with an atom of hydrogen attached to each of the free bonds, viz.:

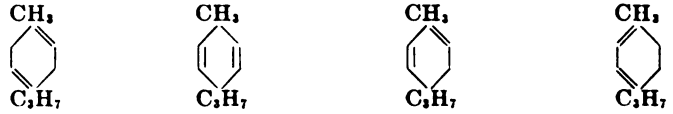
Cymene.



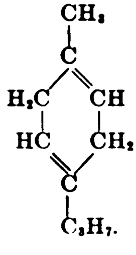
p-Menthadiene.



Since, as mentioned on p. 722, three cymenes containing a normal proply group are known (ortho-, meta-, and para-), so the closely similar terpenes may be found with their methyl and propyl groups in these three positions. Again, we can imagine a new line of terpenes, depending on whether the propyl group is normal or iso. Again, we can have four separate classes of terpenes dependent upon the relative position of the ethylene bond found in the benzene nucleus, as shown in the following figures:



It is hardly necessary to state that the hexagons just given represent the benzene nucleus, with one double bond loosened. Thus, the first one is:



Beside all these combinations of $C_{10}H_{16}$, we can imagine each one of these compounds, containing asymmetric carbon atoms, existing in stereo-isomeric forms, and thus obtaining levogyre, dextrogyre, and inactive terpenes. Lastly, we can carry the isomeric possibilities still further by imagining terpenes containing, instead of methyl and propyl groups above given, two ethyl groups or one ethyl and two methyl groups.

The known terpenes are divided into the following systematic groups:

The Aliphatic Terpenes.—Each molecule of these terpenes absorbs six atoms of bromine, showing the presence of three ethylene groups. Two such terpenes are known, *myricene*, which is found in the oil of bay, and the *anhydrogeraniol*, the formula of which is given on the preceding page, and which is found in the oil of geranium.

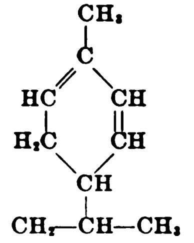
The Limonene Group.—In this group of terpenes each molecule absorbs four atoms of bromine, thereby showing the presence of two ethylene bonds.

Among these terpenes we have the three *limonenes* (d, l, and i); *terpinolene*, an artificial terpene obtained by heating oil of turpentine with alcoholic sulphuric acid;

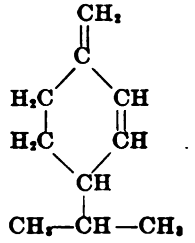
thujene (or *tanacetene*), which is also artificially prepared, and *sylvestrene*, found in Swedish pine needle oil and its inactive isomere, *carvestrene*.

The Terpinene Group consists of two hydrocarbons, *terpinene* and *phellandrene*, the character of which is puzzling. It was formerly thought that neither would absorb bromine, but it is now known that each yields a dibromide. Wallach finds there are two types of phellandrene, the formulas of which are:

α-Phellandrene



β-Phellandrene



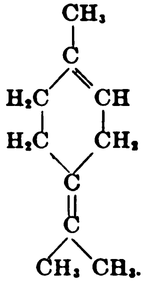
Among the terpenes belonging to this group we find *terpinene*, found in cardamom oil, dextrogyre *phellandrene*, from the oil of phellandrium, and levogyre phellandrene, found in the oil of *Eucalyptus amygdalina*.

The Pinene Group.—Each molecule of this group takes up two atoms of bromine, showing the presence of one ethylene bond. The known terpenes of this group are *pinenes*, two found in the oil of turpentine; *camphene*, found in oil of ginger, and made artificially by Berthelot (the only solid terpene known), *sabinene* found in sandalwood, and *fenchene*, which is an artificial terpene made indirectly from fenchyl alcohol.

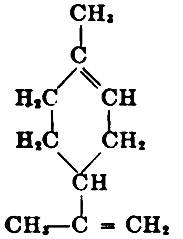
The difference between the different terpenes can best be studied by comparison of a few typical formulas.

Characteristic for the first group given above is the formula of anhydrogeraniol given on p. 726. Of the second group, the formulas ascribed to terpinolene and limonene are as follows:

Terpinolene.

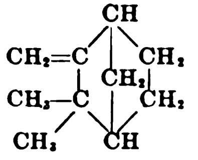


Limonene.

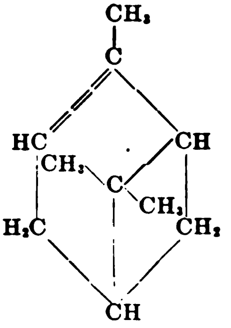


As mentioned above, the structure of the third group is a matter of doubt, while representatives of the pinene group are supposed to have the formulas given below:

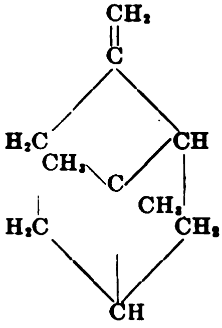
Camphene.



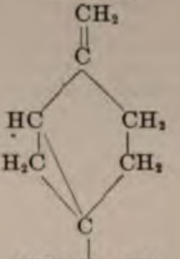
α- pinene.



β- pinene.



Sabinene.



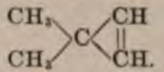
The transformation of one terpene into the other is a comparatively simple matter. Thus, on standing, limonene, found in the oil of lemon, is readily converted into pinene. This explains why the oil of lemon becomes terebinthinate.

Terpenes possess many striking chemical characteristics. For instance, those absorbing bromine generally give very beautiful crystalline bromo-compounds.

Another beautiful line of terpene derivatives are the nitroso-chlorides, such as limonene nitroso-chloride, $C_{10}H_{16}NOCl$, and these, on reduction, frequently yield well-crystallized oximes, such as carvoxime, $C_{10}H_{14}NOH$. Some terpenes are optically active, while others have no effect on the polarized ray of light. Those which do rotate the ray of light to the right or to the left always contain an asymmetric carbon atom (see p. 615).

Another point in the modern consideration of these derivatives is the contraction of the meaning of the word terpene. It was formerly applied to all the derivatives of cymene from $C_{10}H_{14}$ to $C_{10}H_{20}$. In modern chemical nomenclature bodies of the formula $C_{10}H_{16}$ are called terpadienes, while the word terpene is reserved for bodies of the formula $C_{10}H_{18}$, and the substance of the formula $C_{10}H_{20}$ are called terpanes. The application of the word terpene to $C_{10}H_{18}$ is unfortunate, since the word has for years been associated with bodies having the formula $C_{10}H_{16}$. Of the two classes last mentioned, terpenes represent the body $C_{10}H_{16}$, with one of their double bonds loosened and the bonds thus freed taken up with hydrogen atoms, making $C_{10}H_{18}$, while in the terpanes both double bonds are similarly loosened, and taken up by hydrogen, making $C_{10}H_{20}$.

Interesting modifications of the formula $C_{10}H_{16}$ are found in a group of hydrocarbons having the formula C_5H_8. These bodies are called *hemiterpenes;* literally, "half-terpene." An example of such a hemiterpene is *isoprene*, obtained by the distillation of rubber and supposed to have the formula



Again, we have bodies that are modifications of terpenes, containing half as much again carbon and hydrogen as terpenes, and, therefore, having the formula $C_{15}H_{24}$. This class of hydrocarbons are called *sesquiterpenes*. As examples of this may be cited *caryophyllene*, found in oil of cloves, *cadinene*, found in oil of cade, *celinene*, found in oil of celery seed; *santalene*, found in oil of sandalwood; and *zingiberene*, found in oil of ginger. Bodies having formula $C_{20}H_{32}$, $C_{30}H_{48}$, and $C_{40}H_{64}$ are also known.

The subject of terpenes serves as an introduction to that large class —the volatile oils. Practically all volatile oils are mixtures of many chemicals, and the old-fashioned classification of Dumas (1833) into terpenes, oxygenated products, oils containing nitrogen, and those containing sulphur, has long since become antiquated. For this reason the nitrogenated oils and those containing sulphur have already been considered under the appropriate grouping (oils of mustard, see p. 674; oil of bitter almond, see p. 704). Likewise, two other volatile oils that have no connection with the terpenes are the oil of sweet birch and the oil of wintergreen, which are esters of salicylic acid, and have been considered among the derivatives of this chemical. Nor is it wholly correct to consider the rest of the volatile oils merely as terpene derivatives. It is true, in the case of the larger number of them, that most of their bulk consists of terpenes, but it is also true that these oils owe very little of their character to the terpenes. Thus, while oil of lemon consists of about 94 per cent. of the terpene, limonene, this is simply the solvent for the odorous principle, that consisting chiefly of *citral*. In fact, modern chemistry has attempted the problem of obtaining concentrated oils by removing the terpenes, and, in consequence, there is now on the market a large line of the so-called *terpeneless volatile oils*. In many cases these oils are not merely stronger than the natural oils, but are much better for general use. Thus, the terpeneless oil of lemon has, roughly speaking, sixteen times the flavoring power as has the oil of lemon, and possesses the great advantage of not becoming terebinthinate. A very good review of the fallacy of considering the terpenes, or even the terpene derivatives, as the most important constituents of the volatile oils, is found in the admirable paper of Professor Kremers, in the Proceedings of the American Pharmaceutical Association. This paper shows that the volatile oils contain a large number of different esters, aldehydes, alcohols, and ketones.

Two words of the obsolete nomenclature of the volatile oils still used in pharmacy are the terms *eleoptene* and *stearoptene*. These words were coined by Berzelius to represent respectively the liquid and solid portions of volatile oils. As mentioned above, most of the volatile oils are mixtures of quite a number of substances, and it so happens in some cases that some of these substances are solids dissolved in the liquid portion. These solid substances found in oils can sometimes be removed by chilling the oil in a freezing mixture and draining off the unfrozen eleoptene. Among the stearoptenes are found three official substances, camphor, menthol, and thymol. In modern chemistry the question as to whether the constituent of a volatile oil is solid or liquid is of but little importance, and the word stearoptene is not used in the new pharmacopœia.

Beside the official volatile oils containing terpenes, there are several terpene derivatives of interest to pharmacy which can be considered in a purely chemical sense. These are as follows:

Hydrocarbon:	Terebene, U.S.P.
Monatomic alcohols:	Terpineol.
	Menthol, U.S.P.
	Borneol.
Diatomic alcohol:	Terpin hydrate, U.S.P
Aldehyde:	Citral.
Ketone:	Camphor, U.S.P.
Dibasic acid:	Camphoric acid (U.S.P. VIII)
Inner oxide:	Eucalyptol, U.S.P.

TEREBENUM—Terebene

(Tereben.)

A liquid consisting of dipentene and other hydrocarbons, obtained by the action of concentrated sulphuric acid on oil of turpentine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, thin liquid; agreeable thyme-like odor; aromatic terebinthinate taste; soluble in about 2.5 parts of alcohol; slightly soluble in water; resinified on exposure to light and air; sp. gr. 0.860 to 0.865; boils between 160° and 172°C. For details see U.S.P., p. 438.

For *tests for identity*, for *impurities:* Unaltered oil of turpentine (optical rotation not more +0.3° in 100-mm. tube). Rosin (not more than 1 per cent. of residue left on distilling) see U.S.P.

Remarks.—Terebene is a mixture of several terpenes: among them, camphene, dipentene, cymene, and terpinene. Terebene is manufactured by treating 20 parts of oil of turpentine with 100 parts of concentrated sulphuric acid, and allowing the mixture to stand twenty-four hours. It is then heated to boiling, allowed to cool, when the oily layer on top is separated and neutralized with calcium carbonate and then distilled. The distilled terebene is rectified in order to secure a pure product.

Terebene in alcohol solution (1:500) is used as an antiseptic. It is also used in the concentrated form for bronchial troubles, for which purpose it is best given in the form of capsules. When administered for too long a time, however, it is apt to cause irritation of the stomach.

Dose.—¼ mil (4 minims).

Terpineol, $C_{10}H_{17}OH$.—This unofficial chemical is made by the treatment of oil of turpentine with sulphuric acid and nitric acid. Several terpineols are known, three of them being solids and two viscid liquids. The crystalline terpineol is found in commerce, melts at 35°C., and was first obtained from the liquid terpineol by a method which afforded a striking illustration of the possibilities of crystallization. The liquid had been known to chemists, and many efforts have been made to secure its crystallization. All these attempts, such as freezing and the use of the nuclei, etc., have been in vain until Bouchardat and Voiry applied the idea of crystallization by analogy. These chemists had already prepared from India-rubber, by indirect means, a crystalline body having the formula $C_{10}H_{17}OH$, which they called caoutchin hydrate, and a minute crystal of this they dropped into liquid terpineol well cooled by use of a freezing mixture, and immediately the liquid terpineol began to crystallize, and in a short time five-sixths of the mass was solid. From that time the manufacture of crystalline terpineol has been simple, all that was necessary being to add to subsequent batches a few crystals of terpineol, such as originally produced by this brilliant experiment.

Terpineol is not used in medicine, but is largely used in perfumery as the basis of lilac perfumes; the substance in diluted form possesses an agreeable odor resembling that of the lilac blossoms. For perfumery purposes the viscid liquid terpineol, frequently marketed as "lilacin," is preferable to the crystalline.

TERPINI HYDRAS—Terpin Hydrate

(Terpin. Hyd.)

The hydrate [$C_{10}H_{18}(OH)_2 + H_2O = 190.18$] of the dihydric alcohol terpin. Preserve it in well-closed containers, in a cool place.

Summarized Description.

Colorless, lustrous, efflorescent, rhombic prisms, slightly aromatic, somewhat bitter taste; soluble in about 200 parts of water and in about 10 mils of alcohol; also soluble in chloroform, ether and boiling acetic acid; when heated slowly, it sublimes at 100°C.; when heated quickly, it melts between 115° and 117°C. For details see U.S.P., p. 439.

For *tests for identity* see U.S.P.

Remarks.—Terpin hydrate is the crystalline hydrate of terpin, $C_{10}H_{18}(OH)_2$, which in turn can be considered as terpineol, with which one molecule of water has been combined or as a terpene from oil of terpentine (pinene, for example), to which two molecules of water have been added.

The water is, of course, added by chemical means—treatment with diluted mineral acids:

Oil turpentine (or its pinene)	$C_{10}H_{16}$
Add water	HOH
And we get terpineol	$C_{10}H_{17}OH$
Add another water	$H\ OH$
And we get terpin	$C_{10}H_{18}(OH)_2$

Terpin hydrate is generally manufactured by treating an alcoholic solution of oil of turpentine with nitric acid. The mixture is placed in a shallow porcelain dish for three or four days, when the crystals of terpin hydrate appear. The liquid is drained from the same, and the crystals are dried by pressing between sheets of filter-paper. In order to obtain the pure product the substance is recrystallized. The yield of terpin hydrate by this process is about 12 per cent. of the turpentine used.

Terpin hydrate is used in chronic bronchitis and other troubles of the throat.

Dose.—250 milligrammes (4 grains).

Of late years an elixir of terpin hydrate has become quite popular as a cough remedy. Since the chemical does not dissolve in water, the preparation of an elixir which will contain three grains of terpin hydrate to the teaspoonful is a matter of some difficulty. In fact, about the only way to hold the terpin hydrate in solution is by making the preparation strongly alcoholic. A satisfactory recipe for the elixir is found in the National Formulary (p. 210). It, however, contains about 1 grain of terpin hydrate to the teaspoonful. Recipes are also given in the Formulary for this elixir containing heroine and for it containing codeine (p. 210).

MENTHOL—Menthol

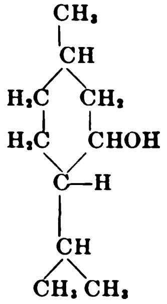
A secondary alcohol [$C_{10}H_{19}OH = 156.16$] obtained from oil of peppermint or other mint oils. Preserve it in well-closed containers, in a cool place.

Summarized Description.

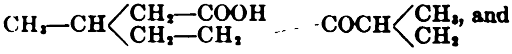
Colorless, acicular or prismatic crystals; strong odor of peppermint; warm aromatic taste, followed by sensation of cold when air is drawn into the mouth; slightly soluble in water; very soluble in alcohol, chloroform, ether, petroleum benzin, liquid petrolatum, fixed and volatile oils; levorotatory; melts between 42° and 44°C.; liquefies when triturated with camphor, thymol or hydrated chloral. For details see U.S.P., p. 272.

For *tests for identity* and for *impurities:* Wax, paraffin or inorganic matter (volatilizes leaving not more than $^5/_{100}$ of 1 per cent. of residue). Thymol (no green color with acetic acid, then sulphuric acid, then nitric acid) see U.S.P.

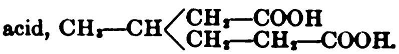
Remarks.—Menthol represents the alcohol of the hydrocarbon menthene, $C_{10}H_{18}$, its graphic formula being as follows:



This formula is proved by its behavior when oxidized with potassium permanganate, when it yields oxymenthylic acid.



$$CH_3{-}CH\begin{cases}CH_2{-}COOH\\CH_2{-}CH_2\end{cases} \cdots COCH\begin{cases}CH_3\\CH_3\end{cases}\text{, and}$$

methyl-adipic acid, 

$$CH_3{-}CH\begin{cases}CH_2{-}COOH\\CH_2{-}CH_2{-}COOH.\end{cases}$$

That menthol is a secondary alcohol is shown by its oxidation by chromic acid into the ketone, menthone, $C_{10}H_{18}O$.

As mentioned in the official definition, menthol is a secondary alcohol ("a stearopten having nature of a secondary alcohol," U.S.P. 1890), found in the oil of peppermint, and is obtained by placing the oil in a freezing mixture, when the menthol should crystallize out.

In the manufacture of menthol from the oil of peppermint the semisolid mass obtained by freezing is thrown on a filter-paper, and after the greater portion of the liquid is drained, the crystals are dried by placing between folds of filter-paper.

This process affords the test for the purity of oil of peppermint, and the pharmacopœia of 1890 gave it among the tests. Unscrupulous distillers remove the menthol from the oil of peppermint and market the liquid part as oil of peppermint. Such an oil yields no menthol when chilled.

Besides the official tests just given, a pretty reaction identifying the menthol is the treatment of menthol with 50 per cent. sulphuric acid, and boiling the mixture, when a blue coloration results.

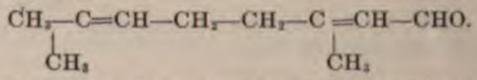
Menthol, as thymol, becomes liquid when triturated with an equal weight of camphor. Such a mixture, containing equal quantities of the two chemicals, plus 5 per cent. of alcohol, to insure permanent fluidity is recognized in the National Formulary under the name, *menthol camphoratum.* Menthol also liquefies when triturated with thymol or chloral hydrate.

Menthol is used as a refrigerant. Its chief use, however, is as the constituent of antiseptic combinations, particularly those used for spraying in the nose. Another use for menthol is in the manufacture of the menthol pencils used for headache. Menthol rubbed on any part of the body evaporates, producing a chilling of the part, and thus involving a mild form of local anesthesia. It is also used in the form of an inhaler, this consisting of glass tubes plugged with cotton at either end, with intervening space loosely filled with menthol crystals, thus affording free access for the passage of air. When the air is sucked through this tube, a certain portion of the menthol volatilizes and enters the throat and nose, where it eventually condenses, thus bringing the healing antiseptic menthol in direct contact with the inflamed surface.

Dose.—60 milligrammes (1 grain).

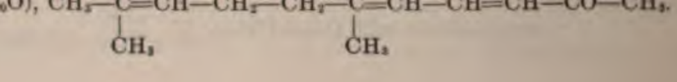
Citral (Geranial), $C_{10}H_{16}O$.—This aldehyde was isolated from oil of lemon in 1888, and found to be the flavoring principle of the oil. Semmler proved it to be identical with geranial, the aldehyde prepared by him by oxidation of geraniol. It is prepared from oil of lemon, which contains from 6 to 8 per cent. of the chemical, and particularly from the lemon grass oils (Andropogon citratus and other species of andropogon), which contains from 60 to 82 per cent., by formation of crystallization compound by treatment of the oil with sodium bisulphite. This compound, after washing with alcohol and ether, is treated with sodium carbonate, and the citral thus freed purified by distillation in vacuo.

As mentioned above, this body is the basis of terpeneless oil of lemon. Chemically, citral is supposed to be the aldehyde of the olefinic hydrocarbon anhydrogeraniol, with formula—



$$CH_3-\underset{\overset{|}{CH_3}}{C}=CH-CH_2-CH_2-\underset{\overset{|}{CH_3}}{C}=CH-CHO.$$

On condensation of this body with acetone there is produced a ketone, pseudo-ionone ($C_{13}H_{20}O$),



$$CH_3-\underset{\overset{|}{CH_3}}{C}=CH-CH_2-CH_2-\underset{\overset{|}{CH_3}}{C}=CH-CH=CH-CO-CH_3.$$

This, on boiling with dilute sulphuric acid and trace of glycerin, yields an isomeric ring compound which is called *Ionone*, and is of great commercial value as the basis of synthetic violet perfume. This is now known to consist of two isomeres, alpha-ionone and beta-ionone.

The real flavor of violet and of orris is still another isomere, called *irone.*

CAMPHORA—Camphor

(Camph.)

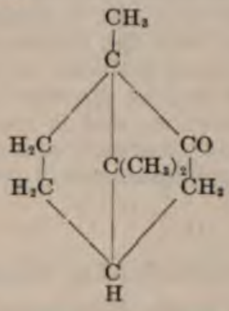
A ketone [$C_{10}H_{16}O$ or $C_9H_{16}CO = 152.13$] obtained from *Cinnamomum Camphora* (Linné) Nees et Ebermaier (Fam. *Lauraceæ*); it is dextrorotatory. Preserve it in well-closed containers, in a cool place.

Summarized Description.

White translucent volatile masses or granules, of tough consistence; characteristic odor; pungent aromatic taste; pulverizable by addition of alcohol, ether or chloroform; slightly soluble in water; soluble in alcohol, chloroform, ether, carbon disulphide, petroleum benzin, oil of turpentine, or in fixed or volatile oils; sp. gr. 0.990; melts between 174° and 177°C., specific rotation $[\alpha]_D$, +41° to +42° in 200-mm. tube, in the proper alcoholic solution. For details see U.S.P., p. 97.

For *tests for identity* and for *impurities:* Chlorinated products (copper wire flame test) moisture (10 per cent.), see U.S.P., p. 97 and also Part V of this book.

Remarks.—While menthol is an alcohol, camphor, as noted above, is a ketone, the oxygen not being combined with hydrogen, but directly attached to a carbon atom.



The synthesis of camphor from pinene has been put upon a commercial basis, but its cost of production has hitherto been too great to make synthetic camphor a very serious competitor to natural camphor under normal conditions.

As mentioned above, camphor is obtained from *Cinnamomum camphora*, a handsome tree growing in Formosa. This tree is cut down, and the roots, trunk, and branches cut into small chips, placed in a rude retort containing heated water. When this water is boiled, the volatile products of the camphor wood distil over. The semisolid distillate is then submitted to hydraulic pressure, which removes all the eleoptene, the stearoptene remaining in the press. The manufacture of this substance affords an interesting and about the only illustration of a volatile oil containing so large a preponderance of the stearoptene as to be semisolid.

The liquid portion separated from the camphor by pressure is comparatively small in quantity, and is marketed under the name of *oil of camphor*, being in considerable demand in the Orient, although its consumption in this country is insignificant. It is well to bear in mind that this oil of camphor is not the familiar camphorated oil (liniment of camphor).

The crude camphor that is separated by expression is mixed with quicklime (to absorb water) and sublimed from a cast-iron retort into a cooled chamber, similar to that used in making flowers of sulphur. The camphor in this case condenses into a fine powder, which is then compressed into cakes.

As already mentioned on p. 118, the powdering of camphor is accomplished by the addition of a small quantity of alcohol, an example of pulverization by intervention. The powder thus obtained has the disadvantage of eventually forming again into a hard cake. Camphor, however, can be kept in the form of a permanent powder by triturating the powder, when freshly made, with a minute trace of white vaseline. Such powdered camphor, of course, would be unfit for preparing solutions, but for the usual purpose for which powdered camphor is employed, the addition of a minute quantity of the harmless substance, white vaseline, does not vitiate the camphor. When a lump of camphor, or powdered camphor free from oil, is placed in water, it floats on the surface, and then very rapidly moves to and fro on the surface of the water. This movement is produced by rapid evaporation of the camphor in contact with the water, and the sudden chilling of the water where the evaporation takes place, causing the movement in the direction where the water is warmer.

Camphor liquefies when triturated with menthol, thymol, chloral hydrate, salol, naphthol and resorcinol; the liquefaction taking place in these cases is not supposed to be due to chemical change, but a mutual solution of the two solids, with the formation of a liquid. And that no chemical change is produced is shown by the fact that such a liquid, when poured into water, is rapidly separated into the two constituents.

Camphor is a mild stimulant and is somewhat diaphoretic. It is used chiefly as anodyne, both internally and externally.

Dose.—By mouth, 200 milligrammes (3 grains): hypodermically, 100 milligrammes (1½ grains).

CAMPHORA MONOBROMATA—Monobromated Camphor

(Camph. Monobrom.)

Ortho-monobromcamphor [$C_{10}H_{15}OBr$ or $C_9H_{15}Br \cdot CO$ = 231.04]. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, prismatic needles, or scales, or powder; mild, characteristic camphoraceous odor and taste; decomposed by exposure to sunlight; soluble in about 5.2 parts of alcohol; also soluble in chloroform or ether; almost insoluble in water; melts between 74° and 76°C. For details see U.S.P., p. 98.

Tests for Identity.—Given above.

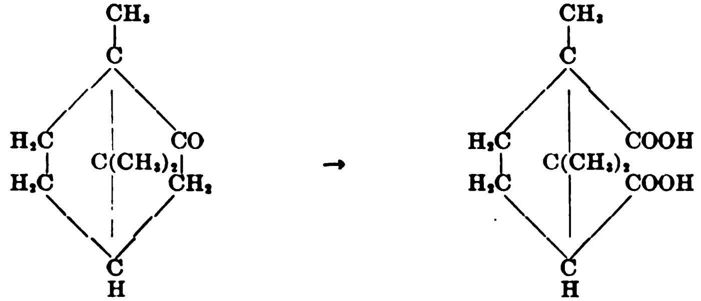
Remarks.—This camphor derivative was discovered by Swarts in 1861, who prepared it by heating camphor and bromine for three hours in a sealed tube on a water-bath. It is generally made by the Maisch process, by mixing bromine and camphor in a retort, heating the mixture to 132°C., then cooling, and extracting the monobromated camphor with benzene. The substance thus obtained is purified by recrystallization.

Monobromated camphor is used as a nervous sedative.

Dose.—125 milligrammes (2 grains).

Acidium Camphoricum (U.S.P. VIII), or *camphoric acid,* is an oxidation product of camphor, nitric acid being the oxidizing agent employed. The oxidation from camphor to camphoric acid can be best explained by the following graphic formulas:

Camphor. Camphoric acid.

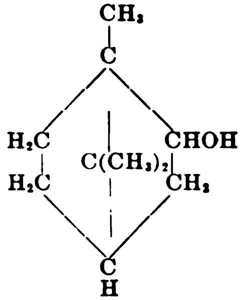


In the description of camphoric acid given in the last pharmacopœia, it was stated among other physical constants that it should in 10 per cent. alcoholic solution the value $[\alpha]_D$ = 47.8°. This means that the specific rotating power of camphoric acid is 47.8°—that is, when examined in a polariscope its solution, under ideal conditions, rotates the ray of light 47.8° to the right.

To convert ordinary conditions of observation to the ideal, it is necessary to use as data in the calculation the observed angle of rotation, the length of the polariscope tube holding the liquid, and the strength of the solution employed. For details see U.S.P. IX, pp. 602 and 603.

Camphoric acid is used as a stimulant as is camphor, but it is claimed to be less irritating. *Dose*, 15 grains.

Borneol, $C_{10}H_{17}OH$.—This is a variety of camphor obtained from the plant, *Dryobalanops Camphora*, and is used quite largely in the east, although not employed in Europe and America. It can be made by treating camphor with sodium alcoholate, and investigations prove that it possesses the following graphic formula:



It differs from camphor in having two extra atoms of hydrogen and in being an alcohol, not a ketone.

EUCALYPTOL—Eucalyptol

(Cineol.)

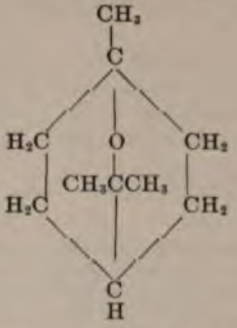
An organic compound [$C_{10}H_{18}O$ = 154.14] obtained from the volatile oil of *Eucalyptus Globulus* Labillardière (Fam. *Myrtaceæ*) and from other sources. Preserve it in well-closed containers, in a cool place, protected from light.

Summarized Description.

Colorless liquid; characteristic, aromatic camphoraceous odor; pungent, spicy taste; cooling to the mouth; very slightly soluble in water, miscible with alcohol, chloroform, ether, glacial acetic acid, fixed and volatile oils; sp. gr. 0.921 to 0.923; boils between 174° and 177°C.; congeals at not less than 0°C. For details see U.S.P., p. 140.

For *tests for identity*, for *impurities*. Oil of eucalyptus and other oils (is optically inactive). Saponifiable oils (volume not diminished on shaking with sodium hydroxide solution). Phenols (solution not colored violet or brown with ferric chloride) see U.S.P., p. 140.

Remarks.—Eucalyptol was originally called *cineol*, because discovered in the oil of the seed of *Artemisia cinæ*, a variety of Levant wormseed. Eucalyptol is made synthetically by treatment of terpineol with phosphoric acid, and this synthesis suggests that eucalyptol is the anhydride of terpin, with the following graphic formula:



On closely examining this formula it is found of interest, inasmuch as the oxygen is placed on the interior of the benzene nucleus. The formula is thus expressed, because while the compound contains oxygen, the substance gives none of the reactions usually obtained from organic chemicals containing oxygen, such as alcohols, aldehydes, ketones, or esters. Eucalyptol is, therefore, supposed to represent one of a unique chemical group called inner oxides.

Eucalyptol is prepared commercially by the fractional distillation of oil of eucalyptus; that portion of the oil distilling between 130° and 180°C. being collected and purified by redistillation over potassa. It is used as an antiseptic and stimulant.

Dose.—0.3 mil (5 minims).

Artificial Musk.—Mention might here be made of the several chemicals, the odor of which so closely resembles that of musk that they can be used in perfumery in place of the natural product.

Of the many varieties, the most important is *musk Baur*, which consists either of trinitrobutyltoluol, $C_6H\left\{\begin{matrix}CH_3\\C_4H_9\\(NO_2)_3\end{matrix}\right.$, or trinitrobutylxylol, $C_6\left\{\begin{matrix}(CH_3)_2\\C_4H_9\\(NO_2)_3\end{matrix}\right.$.

These are made by preparing the appropriate butyl compound by treating toluene or xylene with butyl bromide in the presence of aluminum chloride, and then treating the butyl compound with nitric acid.

Musk Baur occurs in white crystals, soluble in 200 parts alcohol, and this saturated alcoholic solution has perfume strength about equivalent to the official (5 per cent.) tincture of musk.

Too much stress cannot be laid on the fact that the similarity in odor is purely accidental, and that under no circumstances can the artificial be used for the natural musk in medicine.

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Eugenol.—(Structure) Tiemann, B., 9, 1876, 418. (Preparation) Bonastre, Jl. de Ph., 13, 1827, 464; Erlenmeyer, A., 9, 1866, 95.

Safrol.—(Structure) Eijkmann, B., 18, 1885, R. 281. (Source) Binder, Rep. f.d.Ph., 11, 1821, 346; Grimaux and Ruotte, Comp. rend., 68, 1869, 928.

Apiol.—(Structure) Ciamician and Silber, B., 21, 1888, 913 and 1621; 22, 1889, 2481; 23, 1890, 2283; Thoms, B., 36, 1903, 1714. (Source) Homolle and Joret, Jl. de ph. et ch., 28, 1855, 212. (Oleoresin of parsley) Wolff, A.J.P., 49, 1877, 4.

Cymene.—(Structure) Widmann, B., 24, 1891, 439, 970 and 1362. (Behavior) Widmann and Bladin, B., 19, 1886, 583; Schultz, B., 22, 1889, R. 452. (Source) Lallemand, A., 101, 1857, 119; 102, 1857, 117; Bruhl, B., 25, 1892, 150.

Thymol.—(Structure) Widmann, B., 15, 1882, 167; Fittica, A., 172, 1874, 305. (Sources) Arppe, A., 58, 1846, 41; Lallemand, A., 101, 1857, 119. (Properties) Symes, Ph. Jl., [3], 9, 1879, 598; Maisch, A.J.P., 58, 1886, 51.

Thymol Iodide.—(History) Goldman, A.Ph.A., 38, 1890, 625. (Structure and manufacture) Beringer, A.J.P., 63, 1891, 175.

Carvacrol.—(Structure) Jacobsen, B., 11, 1878, 1060. (Synthesis) Reychler, B., 25, 1892, R. 208; Klages, B., 32, 1899, 1516; Wallach, A., 279, 1894, 369. (Source) Jahns, Arch. d. Pharm., 215, 1879, 1.

Carvone.—(Structure) Wallach, A., 279, 1894, 369 and 305, 1899, 233. (Sources) Fluckiger, B., 9, 1876, 47; Wallach, A., 277, 1893, 107. (Optical varieties) Baeyer, Arch. Pharm., 221, 1883, 283; Gladstone, Jl. Ch. Soc., 10, 1872, 1 and 25, 1887, 1.

Terpenes.—(General) Gildemeister-Kremers, The Volatile Oils (1913); Heusler-Pond, The Terpenes (1904); Charabot-Dupont-Pillet, Les Huiles Essentielles (1899); Wallach, A., 24, 1891, 1524; Baeyer, B., 27, 1894, 436; etc. (Anhydrogeraniol) Tiemann and Semmler, B., 28, 1895, 2126. (p. menthadiene) Harries, A., 328, 1903, 322. (Myricene) Power and Kleber, Ph. Rund., 13, 1895, 61. (Limonene) Wallach, A., 239, 1887, 3 and 246, 1888, 222. (Terpinolene) Wallach, A., 227, 1884, 282 and 230, 1885, 272, Baeyer, B., 27, 1894, 436. (Thujene) Wallach, A., 350, 1906, 141; Kizhner, C. A., 6, 1912, 596. (Sylvestrene) Bertram and Walbaum, Arch. d. Pharm. 231, 1893, 299. (Carvestrene) Baeyer, B., 27, 1894, 3485. (Terpinenes) Semmler, B., 34, 1901, 708; Weber, A., 238, 1887, 107; Wallach, A., 374, 1910, 224. (Phellandrenes), Wallach, A., 336, 1904, 10 and 340, 1905, 10. (Camphene) Semmler, B., 42, 1909, 252; Bertram and Walbaum, Jl. prakt. Ch., [2], 49, 1894, 18. Berthelot, Comp. rend., 55, 1862, 496 and 544. (Limonene) Semmler, B., 28, 1895, 2143 and 33, 1900, 1455. (Pinenes) Wagner, B., 27, 1894, 2275; Wallach, A., 227, 1885, 300 and 363, 1908, 9. (Sabinene) Semmler, B., 35, 1902, 2045.

Terpene Nomenclature.—Baeyer, B., 27, 1894, 436.

Hemiterpenes.—(Isoprene) Wendt, Ph. Zt., 52, 1907, 331; Pond, Jl. Am. Ch. Soc., 36, 1914, 165.

Sesquiterpenes.—(Caryophyllene) Wallach, and Walker, A., 271, 1892, 285; Deussen, Loesche and Klemm, A., 369, 1909, 41. (Cadinene) Wallach, A., 271, 1892, 297. (Celinene) Semmler and Risse, B., 45, 1912, 3301. (Santalene) Semmler, B., 40, 1907, 1120. (Zingiberene) Soden and Rogalen, Ph. Zt., 45, 1900, 414.

Volatile Oils.—(General) Kremers, A.Ph.A., 46, 1898, 214. (Classification) Dumas, A., 6, 1833, 245; Berzelius, Lehrbuch der Chemie, 6, 1837, 580. (Antiseptic value) Martindale, Ph. Jl., 85, 1910. 668; Gilmour, A.Ph.A., 58, 1910, 293. (Terpeneless oils) Schimmel's Rep., Apr., 1893, 33 and 76.

Terebene (Composition and manufacture) Power and Kleber, Ph. Rund., 12, 1894, 16.

Terpineol.—(Structure) Wallach, B., 28, 1895, 1773. (Properties) Bouchardat and Voiry, Comp. rend., 104, 1887, 996.

Terpin Hydrate.—(Structure) Baeyer, B., 26, 1893, 2865. (Manufacture) Wallach, A., 227, 1885, 284; Hahn, A.J.P., 69, 1897, 73. (Uses) Lepine, Am. Dr., 15, 1886, 15. (Elixir) McClintock, A.J.P., 73, 1901, 31; Hain, Apothecary, 7, 1910, 20.

Menthol.—(Structure) Arth, B., 19, 1886, R., 436 (Preparation) Todd, A.J.P., 58, 1886, 159. (Tests) Fritsche, A.Ph.A., 34, 1886, 541. (Properties) Kyle, A.Ph.A., 34, 1886, 541.

Citral.—(Structure and properties). Tiemann, B., 31, 1898, 3278, 3297 and 3324. (Sources) Dodge, Am. Ch. Jl., 11, 1889, 456 and 12, 1890, 563; Kremers, Dr. Circ., 59, 1915, 355.

Ionones and Irones.—Tiemann and Krueger, B., 26, 1893, 2675; Tiemann, B., 31, 1898, 808 and 867; Kraemer, A.J.P., 67, 1895, 346; Sadtler, A.J.P., 81, 1909, 181.

Camphor.—(Structure) Bredt, B., 26, 1893, 3049. (Synthesis) Reychler, B., 29, 1896, 695; Semmler, B., 33, 1900, 3420; Pond, Jl. Soc. Ch. Ind., 26, 1907, 383. (Source) Rusby, Jl. Soc. Ch. Ind., 26, 1907, 380; Duncan, Harper's Magazine, 122, 1911, 381; Houseman, A.J.P., 87, 1915, 49. (Synthetic camphor) Lenz., Arch. d. Pharm. 249, 1911, 286. (Properties) LaWall, Merck's Rep., 19, 1910, 1; Matteuci, A.J.P., 6, 1839, 174; Rayleigh, Ch. and Dr., 36, 1890, 707. (Powdering) Lowd, A.Ph.A., 19, 1871, 441; England, A.J.P., 59, 1887, 598. (Camphor chloral) Brown, A.Ph.A., 22, 1874, 232. (Other liquefactions) Caille, Comp. rend., 148, 1910, 1458.

Oil of Camphor.—Lallemand, A.J.P., 32, 1860, 265; MacEwan, Ph. Jl., [3], 15, 1885, 1045.

Mono-bromated Camphor.—Maisch, A.J.P., 44, 1872, 337.

Camphoric Acid.—(Structure) Bredt, B., 26, 1893, 3049. (Synthesis) Kamppa, Jl. Ch. Soc., 99, 1911, 29. (Uses) Reichert, Ph. Jl., [3], 19, 1888, 507.

Borneol.—(Structure) Wagner, B., 32, 1899, 2324. (Source) Anon., Ph. Jl., [3], 12, 1881, 83. (Synthesis) Wallach, A., 230, 1885, 225.

Eucalyptol.—(Structure) Wallach, A., 258, 1890, 335 and 291, 1896, 350. (Synthesis) Wallach, A., 239, 1887, 21. (Sources) Wallach and Brass, A., 225, 1884, 291; Jahns, B., 17, 1884, 2941.

Synthetic Perfumes.—(Musk) Baur, B., 24, 1891, 2832. (General) Mann, Die moderne Perfumerie. Brittain, Ch. and Dr., 85, 1914, 59; Umney, Perf. Ess. Oil. Rec., 2, 1911, 134.

CHAPTER XLVII

VOLATILE OILS AND VOLATILE OIL DRUGS

A LARGE number of volatile oils and drugs depending for their activity upon volatile oils are recognized by the pharmacopœia, and these we will study in the following order:

I. Official volatile oils obtained from unofficial drugs.
II. Official drugs containing volatile oil.
III. Official drugs containing volatile oil and resin.
IV. Official drugs containing volatile oil and bitter principle.
V. Official oleoresins.
VI. Official balsams.

Official volatile oils not considered in the first group will be studied under the drug whence they are derived.

OFFICIAL VOLATILE OILS OBTAINED FROM UNOFFICIAL DRUGS

The chemistry of volatile oils has been studied on p. 728, but before taking up the individual members of the group a few words as to the physical difference between fixed and volatile oils may be advisable. The general test for distinction—in fact, expressed in the names "fixed," and "volatile"—was touched upon in discussing fixed oils (p. 653).

Drop some of the liquid on a piece of paper, and warm the stain over a lamp; if a volatile oil, the stain disappears; if a fixed oil, it remains.

A very homely test is the behavior of a glass stopper toward fixed and volatile oils. The ground-glass stopper of a bottle containing a fixed oil rotates easily and quietly in the neck, whereas a volatile oil stopper, when twisted in the neck, makes a squeaking noise under the operation.

The **separation of volatile oils** from their original sources varies according to the nature of oil, the character of the plant part whence derived, and other considerations. The methods can, however, be roughly classified into the following groups:

I. *Distillation with Water.*—In this case the drug is placed in a still with cold water, care being taken to prevent the drug from touching the bottom of the still, for if so exposed, the plant part is apt to scorch, thus vitiating the odor of the distillate (p. 102). The water is then slowly and carefully heated, and as it distils it carries over with it the volatile oil found in the plant. This is the process by which most crude oils are distilled in their native home, especially those distilled in the Orient. Example, oil of cajuput.

II. *Distillation with Steam.*—This process has already been fully described (p. 102), hence it is merely necessary to say that it is employed in place of distillation with water by all progressive distillers of oils produced in Europe and America. This is the way that oil of peppermint is now obtained in Michigan.

III. *Distillation Alone.*—This process is applied in the case of some crude cheap oils, such as the manufacture of oil of turpentine from its oleoresin, which is placed in a still and cautiously heated until all the oil passes over. The residue in the still in the case considered constitutes official rosin. Even in the case of oil of turpentine, some distillers introduce a small stream of water into the distilling mass to lessen the danger of scorching.

IV. *Destructive Distillation.*—The so-called oils obtained by this process, which has already been described on p. 103, are in truth tarry products, and no longer classed among the true oils. An example of these is the official oil of cade.

V. *Vacuum Distillation.*—This process, described, on p. 103, is practically never used in obtaining a crude oil from its plant sources, but is used largely in refining crude oils.

VI. *Expression.*—The oils from the rind of the fruits of the Citrus family—lemon, orange, bergamot, etc.—reside in the outer layer of cells, hence can be obtained by expression. This process is used in these cases because the distillation of the rind yields an inferior oil. The extraction of the oil is accomplished either by pressing the quarter or half fruit against a sponge, which is eventually expressed into the container, or by the use of a complicated machine which ruptures the oil-cells by scraping, and then pressing the broken cells against sponges. This machine works well only with the round fruits, orange and bergamot, being useless in the case of lemon.

The *ecuelle à piquer* is a hollow bowl disk studded with needles on its concave side, and provided with a hollow handle which collects the oil separated from the rind by the pricking of needles when the instrument is revolved against the fruit. It is not used much at present.

VII. *Enfleurage.*—This method is employed in removing from flowers odors too subtle to stand distillation and too scarce to permit of expression. Briefly explained, the process consists of bringing the fresh flowers in contact with lard made odorless by prolonged washing with water. The lard is spread on glass plates in thin layers, and thereon are thrown the flowers, usually prevented from direct contact with the lard by having wire netting interposed. When the flowers wither, new ones are spread on the netting, and the batches are renewed until the lard has the sufficient amount of odor. Such odorous lard is called a *pomade*, the qualifying phrases *triple* and *quadruple* meaning that the lard has been impregnated with the odor of three or four times its weight of flowers respectively. The pomades are usually made direct into perfume by mixing the lard with cologne spirit (p. 590), which dissolves the perfume, but not the fat. The latter is then separated by filtration. The filtrate forms the perfumer's *extract*, the standard strength of which is the filtrate from a mixture of 1 kilo of pomade and 1250 mils cologne spirit. While the odorous principles of flowers are known to be volatile oils, only recently have efforts been made to isolate the oil, perfumers finding that the extracts above described answered their purpose. The volatile oil of jasmin has, however, been isolated by Verley by shaking the pomade with liquid petrolatum, which absorbs the oil, and extracting the latter from its petroleum solution by shaking with acetone.

VIII. *Percolation.*—Of late, perfume chemists have been extracting floral volatile oils more or less associated with solid fats by percolating the flowers with low-boiling solvents, such as methyl chloride. It is beyond the limits of this work to give more than this brief statement as to extraction of volatile oils, and for further details the reader is referred to the books on volatile oils and perfumes cited in the bibliography.

OLEUM CAJUPUTI—Oil of Cajuput

(**Ol. Cajup.**—Cajuput Oil—Oil of Cajeput)

A volatile oil distilled from the fresh leaves and twigs of several varieties of *Melaleuca Leucadendron* Linné, especially the var. *Cajeputi* Roxburgh and the var. *minor* Smith (Fam. *Myrtaceæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place.

Summarized Description.

Colorless or yellowish liquid; peculiar, agreeable camphoraceous odor; aromatic, slightly bitter taste; soluble in 1 volume of 80 per cent. alcohol; sp. gr. 0.912 to 0.925; optical rotation, −4° in 100-mm. tube. For details see U.S.P., p. 288.

For *tests for identity* and for *impurities:* (heavy metals) see U.S.P., p. 288 and also Part V of this book.

Composition.—Cineol (p. 735), 55 per cent., a solid terpineol, small amount of terpenes, aldehydes, etc.

Remarks.—The green color of most cajuput oil is due to the copper absorbed from the still.

Medical Properties.—Stimulant and rubefacient.

Dose.—0.5 mil (8 minims).

OLEUM CHENOPODII—Oil of Chenopodium

(**Ol. Chenopod.**—Oil of American Wormseed)

A volatile oil distilled from *Chenopodium ambrosioides anthelminticum* Linné (Fam. *Chenopodiaceæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid; characteristic disagreeable odor and taste; soluble in 8 volumes of 70 per cent. alcohol; optical rotation −4° to −10° in 100-mm. tube. For details see U.S.P., p. 290.

Composition.—A terpene, $C_{10}H_{16}$, *ascaridole*, $C_{10}H_{16}O_2$, an unstable organic dioxide, exploding when heated with mineral acids.

Remarks.—The "optical rotation," mentioned in the official definition, refers to the deflection of the ray of light when passing through 100 millimeters of the oil contained in the tube of a polarizing apparatus (p. 735). Explanatory of the measurement of the angle in this case (−4° to −10°), it may be stated that the minus sign means a rotation to the left (lævogyrate), while the 4° of rotation is based on the standard

360° of the circle. If the substance rotated the ray of light 5° to the right, it would be expressed "+5°." This statement as to the angle of rotation is here given not only to explain this particular case, but also because similar data are given regarding many of the oils of the present pharmacopœia.

Medical Properties.—Anthelmintic, usually administered mixed with castor oil. The oil is distinctly toxic, because of the ascaridole which it contains.

Dose.—0.2 mil (3 minims).

Chenopodium, or *American wormseed,* was official in the pharmacopœia of 1890. Its only important constituent is the oil described above.

Oleum Erigerontis (U.S.P. VIII) or *oil of erigeron* is distilled from the fresh flowering herb of *Erigeron canadensis.* It contains dextrogyrate limonene and is used as a hemostatic and stimulant.

OLEUM JUNIPERI—Oil of Juniper

(**Ol. Junip.**—Juniper Oil—Oil of Juniper Berries)

A volatile oil distilled from the ripe fruit of *Juniperus communis,* Linné (Fam. *Pinaceæ*). Preserve it in well-stoppered, amber-colored bottles in a cool place, protected from light.

Summarized Description.

Colorless, faintly green or yellow liquid; characteristic odor and taste; soluble in 4 volumes of alcohol; sp. gr. 0.854 to 0.879; optical rotation, 0° to −15° in 100-mm. tube. For details see U.S.P., p. 293.

Composition.—Pinene, cadinene, a terpineol, $C_{10}H_{17}OH$, borneol and iso-borneol.

Medical Properties.—Stimulant, diuretic. *Gin* (p. 182) is an alcoholic solution of this oil prepared by distilling fermented juniper berries, and is simulated in the official *compound spirit of juniper* (p. 182). The simple *spirit of juniper* (p. 181) is also official.

Dose.—Of oil, 0.2 mil (3 minims).

Juniperus (U.S.F. VIII; N.F. IV) is the fruit of *Juniperus communis.* Beside the oil (about 1 per cent.) the berries contain fruit acids, pectin, protein and resins. It is a popular domestic diuretic. *Dose,* 1 drachm.

OLEUM LAVANDULÆ—Oil of Lavender

(**Ol. Lavand.**—Oleum Lavandulæ Florum, U.S.P. VIII)

A volatile oil distilled from the fresh flowering tops of *Lavandula vera* De Candolle (*Lavandula officinalis* Chaix, *Lavandula spica* Linné) (Fam. *Labiatæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or yellow liquid; characteristic odor and taste; soluble in 3 volumes of 70 per cent. alcohol; sp. gr. 0.875 to 0.888; optical rotation, −1° to −10° in 100-mm. tube. For details see U.S.P., p. 294.

For *tests for identity,* for *impurities:* alcohol (volume not diminished by shaking with water). Esters (modified volumetric test) see U.S.P., p. 294.

Composition.—Lævogyrate linalyl acetate, 30 to 45 per cent.; geraniol, some terpenes, etc.

Remarks.—*Oil of spike* is a crude oil of lavender, made by distilling the lavender herb. Most of the oil of spike in the American market is a factitious product.

Medical Properties.—Stimulant. Used mostly as perfume. Official

preparations: *Spirit of lavender* (p. 182) and *compound tincture of lavender* (p. 229). A constituent of *aromatic spirit of ammonia* (p. 454).
Dose.—0.2 mil (3 minims).

Oleum Rosæ (U.S.P. VIII), or *otto of rose*, is a volatile oil distilled from the fresh flowers of *Rosa damascena*. It consists of a liquid portion containing geraniol, (p. 732), 70 per cent.; citronellol, 20 per cent.; esters, 2.5 to 3.5 per cent.; and a stearopten which is a mixture of paraffin hydrocarbons.

The pure oil is very expensive, since it requires 3000 kilos of fresh petals to yield one kilo of oil; hence the commercial article is grossly adulterated—at place of distillation in Bulgaria—with palmarosa oil (Turkish geranium oil), and in the open market with a host of other substances.

As these adulterants contain no stearopten, the congealing point test of the former pharmacopœia was aimed to distinguish the pure oil from adulterated specimens, but as the spermaceti is added to sophisticated oils to make up for the lack of the true stearopten, the test loses some of its value. As palmarosa oil consists largely of geraniol, assays for that body have no value in determining purity of rose oil; hence chemists rely chiefly on the saponification figures such as described in Part V. While the saponification number of oil of rose is 10 to 17, that of palmarosa oil is 30 to 50.

Oil of rose is used almost exclusively as a perfume.

OLEUM ROSMARINI—Oil of Rosemary

(Ol. Rosmar.—Rosemary Oil)

A volatile oil distilled from the fresh flowering tops of *Rosmarinus officinalis* Linné (Fam. *Labiatæ*), yielding not less than 2.5 per cent. of ester, calculated as bornyl acetate [$C_{10}H_{17}C_2H_3O_2 = 196.16$] and not less than 10 per cent. of total borneol [$C_{10}H_{17}OH = 154.14$]. Preserve it in well-stoppered, amber-colored bottles in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid; characteristic odor; camphoraceous taste; soluble in 10 volumes of 80 per cent. alcohol; sp. gr. .0894 to 0.912. For details see U.S.P., p. 300.

For *assay* see U.S.P., p. 300 and also Part V of this book.

Composition.—Pinene, camphene, cineol, camphor, borneol, esters, etc.

Remarks.—It will be seen from the official definition that the official oil must contain 2.5 per cent. of ester and 10 per cent. borneol. The ester estimation is by saponification number, while the borneol is assayed by means of the acetylization test. These latter, like the saponification test, will be explained in chapter on Volumetric Analysis (p. 914).

Medical Properties.—Carminative.

Dose.—0.2 mil (3 minims).

OLEUM SANTALI—Oil of Santal

(Ol. Santal.—Santalwood Oil—Oil of Sandalwood)

A volatile oil distilled from the wood of *Santalum album* Linné (Fam. *Santalaceæ*), yielding not less than 90 per cent. of alcohols, calculated as santalol [$C_{15}H_{26}O = 222.21$]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Pale yellow, somewhat thick liquid; characteristic odor; soluble in 5 volumes of 70 per cent. alcohol; sp. gr. 0.965 to 0.980; optical rotation, −15° to −20° in 100-mm. tube. For details see U.S.P., p. 300. For *assay* see U.S.P., p. 300 and also Part V of this book.

Composition.—Santalol (a mixture of two isomeric alcohols, $C_{15}H_{24}O$); santalene (a mixture of two isomeric sequiterpenes, $C_{15}H_{24}$); a santalol (an aldehyde, $C_{11}H_{16}O$); santanone (a mixture of ketones, including true santanone, $C_{11}H_{16}O$, and nor-camphor, $C_9H_{14}O$); santanone alcohol, $C_9H_{16}O$;

a hydrocarbon, $C_{11}H_{18}$; teresantalol, an alcohol, $C_{10}H_{16}O$; teresantalic acid, $C_9H_{13}COOH$, and esters of the above-mentioned alcohols and acids.

Remarks.—It will be noted that this oil comes from a different source than the official red saunders.

Medical Properties.—Antiseptic in gonorrhea.

Dose.—0.5 mil (8 minims).

OLEUM THYMI—Oil of Thyme

(Ol. Thymi—Thyme Oil)

A volatile oil distilled from the flowering plant of *Thymus vulgaris* Linné (Fam. *Labiatæ*), and containing not less than 20 per cent., by volume, of phenols. Preserve it in well-stoppered, amber-colored bottles, in a cool place protected from light.

Summarized Description.

Colorless or red liquid; characteristic odor and taste; soluble in 2 volumes of 80 per cent. alcohol; sp. gr. 0.894 to 0.930; slightly levorotatory. For details see U.S.P., p. 304.

For *tests for identity*, for *impurities*, phenol (aqueous solution not colored blue or violet by ferric chloride).

Outline of Assay.—Shake in a cassia flask with sodium hydroxide solution and then fill flask up to the graduations in the neck. Insoluble part should represent not more than 80 per cent. of the original volume. For details see U.S.P.

Composition.—Thymol, cumene, levorotatory pinene, borneol, linalool, carvacrol, etc.

Remarks.—The valuation of oil of thyme is based by the U.S.P. IX on the phenol content, which should be at least 20 per cent. The assay given above depends on the fact that the phenols, when treated with alkali, saponify and become soluble in water. Thus, from what was originally 10 mils of water-insoluble oil, 2 mils become soluble through action of alkali, leaving 8 mils of water-insoluble residue.

Medical Properties.—Carminative and antiseptic.

Dose.—0.2 mil (3 minims).

VOLATILE OIL DRUGS

VALERIANA—Valerian

(Valer.)

The dried rhizome and roots of *Valeriana officinalis* Linné (Fam. *Valerianaceæ*).

Constituents.—Volatile oil, resin, acids, etc.

The volatile oil is composed of the terpenes, camphene and pinene; borneol esters, chiefly the valerianate, 9.5 per cent., and several other bodies. It is now thought that all the valerianic acid present is in the form of the ester above mentioned.

Medical Properties.—Sedative in hysteria. Administered as *tincture*, U.S.P. (p. 233), and the *ammoniated tincture*, U.S.P. (p. 233). The valerianates, especially ammonium valerianate, are popular, an elixir of which is recognized by the National Formulary (p. 207).

Dose.—Of drug, 2 grammes (30 grains).

VIBURNUM PRUNIFOLIUM—Viburnum Prunifolium

(Viburn. Prun.—Black Haw—Viburnum)

The dried bark of *Viburnum prunifolium* Linné or of *Viburnum Lentago* Linné (Fam. *Caprifoliaceæ*), without the presence or admixture of more than 5 per cent. of wood or other foreign matter.

Constituents.—Valeric acid and bitter, resinous principles, one of the latter being called *viburnin.*

Remarks.—This bark is placed in this chapter merely for the lack of a better position. If it possesses any medicinal activity, it is due to the valerianic acid it contains, hence they can best be considered along with valerian. Bear in mind, however, that the *drug contains no volatile oil,* hence its study in this chapter is, to a certain extent, inconsistent and possibly misleading.

Medical Properties.—The drug is popularly esteemed as nervines, especially in internal disorders; having been of late largely advertised among physicians, through the exploiting of a proprietary prescription. The present pharmacopœia recognizes the *fluidextract* (p. 244) and the *extract* (p. 280).

Dose.— 2 grammes (30 grains).

Viburnum Opulus (U.S.P. VIII; N.F. IV), or *cramp bark,* is properly obtained from *Viburnum opulus,* var. *Americanum* (Miller) Aiton (Fam. *Caprifoliaceæ*) although much of the viburnum opulus of commerce consists almost entirely of the bark of Acer spicata. Its value, if any, like that of black haw, is due to the valerianic acid which it contains. *Dose,* 30 grains.

SASSAFRAS—Sassafras

(Sassaf.)

The bark of the root of *Sassafras variifolium* (Salisbury) O. Kuntze (Fam. *Lauraceæ*), without the presence or admixture of more than 2 per cent. of adhering wood, collected in the early spring or autumn, deprived of the outer corky layer and dried.

Constituents.—Volatile oil, 7 per cent.; resin, a tannin-like body called *sassafrid,* tannic acid, etc.

Medical Properties.—Carminative, diaphoretic (as hot infusion).

Dose.—10 grammes (2½ drachms).

OLEUM SASSAFRAS—Oil of Sassafras

(Ol. Sassaf.—Sassafras Oil)

A volatile oil distilled from the root of *Sassafras variifolium* (Salisbury) O. Kuntze (Fam. *Lauraceæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Yellow or reddish-yellow liquid; characteristic odor and taste; soluble in 2 volumes of 90 per cent. alcohol; sp. gr. 1.065 to 1.077; optical rotation +3° to + 4° in 100-mm. tube. For details see U.S.P., p. 301.

Composition.—Safrol, 80 per cent.; pinene and phellandrene, 10 per cent.; dextrogyrate camphor, 6.8 per cent.; eugenol, sesquiterpenes, etc.

Medical Properties.—Stimulant and carminative. Used largely in liniments.

Dose.—0.2 mil (3 minims).

CINNAMOMUM SAIGONICUM—Saigon Cinnamon

(Cinnam. Saigon.)

The dried bark of an undetermined species of *Cinnamomum* (Fam. *Lauraceæ*).

CINNAMOMUM ZEYLANICUM—Ceylon Cinnamon

(Cinnam. Zeylan.)

The dried bark of cultivated trees of *Cinnamomum zeylanicum* Breyne (Fam. *Lauraceæ*), without the presence or admixture of more than 3 per cent. of the outer bark or other foreign matter.

Constituents.—Both barks contain volatile oil, mucilage, only traces of starch, etc.

Remarks.—These two barks are similar in properties, but widely different in appearance, Saigon cinnamon being in pieces not unlike ordinary barks of same sizes; while Ceylon cinnamon, which is the inner bark, is as thin as paper, and comes in tightly rolled quills. The oil from these two barks is not identical with the official oil.

Official preparations (all from the Saigon bark): *Tincture cinnamon, compound tincture of cardamom, compound tincture of gambir, compound tincture of lavender, aromatic tincture of rhubarb,* and *aromatic powder.*

Medical Properties.—Carminative, flavor.

Dose.—Of each bark, 250 milligrammes (4 grains).

Cassia cinnamon, the bark of *Cinnamomum Cassia,* was recognized by the pharmacopœia of 1890, but was dropped in the eighth revision.

OLEUM CASSIÆ—Oil of Cinnamon

(**Ol. Cass.**—Oleum Cinnamomi, U.S.P. VIII—Cassia Oil)

A volatile oil distilled from *Cinnamomum Cassia* (Nees) Blume (Fam. *Lauraceæ*), rectified by steam distillation and yielding not less than 80 per cent. by volume of cinnamic aldehyde [C_9H_8O = 132.06]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Yellowish or brownish liquid, darkens and thickens on aging and on exposure to the air; characteristic odor and taste; sp. gr. 1.045 to 1.063; optical rotation, +1° to − 1° in 100-mm. tube. For details see U.S.P., p. 290.

For *tests for identity,* for *impurities:* Heavy metals (hydrogen sulphide test). Rosin (solution in petroleum benzine not turned green by shaking with copper acetate solution) for *assay* see oil of caraway.

Composition.—Cinnamic aldehyde, 75 per cent.; methyl-orthocumaric aldehyde, cinnamyl acetate, free cinnamic acid, etc.

Remarks.—It will be noted that the official definition given above does not specify which part of the Cassia cinnamon plant furnishes the oil. In truth, all parts yield it, but the commercial source is usually the leaves and twigs. The oil is not identical with that from Ceylon cinnamon; in fact, the only point of similarity is that the bulk of both oils consists of cinnamic aldehyde (p. 721). Cinnamic acid present in the oil attacks metals, and as the oil is shipped from China in lead containers, that metal is apt to be found in the oil; hence the pharmacopœial test for heavy metals.

Medical Properties.—Stimulant, rubefacient, flavor. Used in preparing *cinnamon water,* U.S.P. (p. 176), and *spirit of cinnamon,* U.S.P. (p. 181).

Dose.—0.2 mil (3 minims).

EUCALYPTUS—Eucalyptus

(**Eucalypt.**—Blue Gum Leaves)

The dried leaves of *Eucalyptus Globulus* Labillardière (Fam. *Myrtaceæ*), collected from the older parts of the tree, without the presence or admixture of more than 3 per cent. of the stems, fruits and other foreign matter.

Constituents.—Volatile oil, 6 per cent.; chlorophyll, resin, tannin, etc.

Medical Properties.—Stimulant, carminative, antiseptic. The *fluidextract* (p. 244) is official.

Dose.—2 grammes (30 grains).

OLEUM EUCALYPTI—Oil of Eucalyptus

(Ol. Eucalypt.—Eucalyptus Oil)

A volatile oil distilled from the fresh leaves of *Eucalyptus Globulus* Labillardière (Fam. *Myrtaceæ*) or from some other species of *Eucalyptus*, and yielding not less than 70 per cent., by volume, of eucalyptol (cineol) [$C_{10}H_{18}O$ = 154.14]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale-yellow liquid; characteristic camphoraceous odor; pungent spicy, cooling taste; soluble in 4 parts of 70 per cent. alcohol; sp. gr. 0.905 to 0.925. For details see U.S.P., p. 291.

For *tests for identity*, for *impurities:* Other eucalyptus oils containing much phellandrene (no crystals of phellandrene nitrite when treated with sodium nitrite and glacial acetic acid).

Outline of Assay.—Form eucalyptol arsenate by treating the oil with arsenic acid T. S. at 0°C. Carefully dry this between filter paper, transfer to a cassia flask, add hot distilled water and read volume of the separated eucalyptol. For details see U.S.P., p. 292.

Composition.—Eucalyptol (or cineol), 50 per cent.; dextrogyrate pinene; other terpenes (little or no phellandrene), etc.

Remarks.—The cineol assay given above is based on the formation of solid cineol arsenate. The dried precipitate is then transferred to a cassia flask and is treated with warm water, when the cineol separates as an oily liquid, and its volume can be measured. Ten mils of oil should by this process yield 7 mils of cineol. Note that cineol is official (see Eucalyptol, p. 735).

Medical Properties.—Antiseptic.

Dose.—0.5 mil (8 minims).

BUCHU—Buchu

The dried leaves of *Barosma betulina* (Thunberg) Bartling and Wendland, known in commerce as Short Buchu; or of *Barosma serratifolia* (Curtis) Willdenow, known in commerce as Long Buchu (Fam. *Rutaceæ*), without the presence or admixture of more than 10 per cent. of stems and other foreign matter.

Constituents.—Volatile oil, fat, mucilage, chlorophyll, etc.

Remarks.—The *volatile oil* contains a stearopten, *diosphenol* (a phenol, $C_{10}H_{16}O_2$, which turns green black with ferric chloride), while the eleoptene consists of a terpene, $C_{10}H_{18}$, and a ketone resembling menthone.

Remarks.—The most prominent characteristic of this valuable drug of South Africa is its peculiar and pleasant odor.

Medical Properties.—Stimulant, diuretic. Administered as infusion and as *fluidextract*, U.S.P. (p. 244).

Dose.—2 grammes (30 grains).

Hedeoma (U.S.P. VIII), or *pennyroyal*, is the dried leaves and flowering tops of *Hedeoma pulegioides* (Linné) Persoon (Fam. *Labiatæ*). Its chief constituent is its volatile oil. It is used as a diaphoretic, emmenagogue, carminative, in 120-grain doses.

Oleum Hedeomæ (U.S.P. VIII), or *oil of pennyroyal*, is distilled from the leaves and flowering tops of Hedeoma. It contains pulegone, $C_{10}H_{16}O$ (24 per cent.), methyl-cyclohexanone (6 per cent.), menthones (50 per cent.), pinene, limonene, dipentene, a sesquiterpene alcohol, a phenol, formic, butyric and other acids, free and combined. It is an emmenagogue and as it is frequently used as an abortificient, its sale is prohibited in many States. *Dose*, 3 minims.

MENTHA PIPERITA—Peppermint

(Menth. Pip.)

The dried leaves and flowering tops of *Mentha piperita* Linné (Fam. *Labiatæ*).

Constituents.—Volatile oil, tannic acid, etc.

Medical Properties.—Carminative, stimulant, flavor. The herb is used to color the official *spirit of peppermint* (p. 182).

Dose.—4 grammes (60 grains).

OLEUM MENTHÆ PIPERITÆ—Oil of Peppermint

(Ol. Menth. Pip.—Peppermint Oil)

A volatile oil distilled from the flowering plant of *Mentha piperita* Linné (Fam. *Labiatæ*), rectified by steam distillation, and yielding not less than 5 per cent. of esters, calculated as menthyl acetate [$C_{10}H_{19}C_2H_3O_2 = 198.18$], and not less than 50 per cent. of total menthol [$C_{10}H_{19}OH = 156.16$], free and as esters. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless liquid, strong odor of peppermint; pungent taste, followed by sensation of cold when air is drawn into the mouth; soluble in 4 volumes of 70 per cent. alcohol; sp. gr. 0.896 to 0.908; optical rotation, −23° to −33° in 100-mm. tube. For details see U.S.P., p. 295.

For *tests for identity*, for *impurities:* Dimethyl sulphide (no white film when first part of distillate is poured upon mercuric chloride T. S., and for *assay* see U.S.P., p. 296 and also Part V of this book.

Assay.—For esters and for menthol, see Part V.

Composition.—Menthol, U.S.P.; methyl acetate; menthene and fourteen other bodies.

Remarks.—The different peppermint oils—American, English, Japanese, German—are not identical in chemical composition, the statement just given referring to the American oil. Thus the Japanese oil contains 70–91 per cent. total menthol, the English 58 to 66 per cent., while the American has 50 to 60 per cent. The menthol content was formerly considered the criterion of quality of the oil; hence the test provided in the former pharmacopœias that a sample of oil placed in freezing mixture should yield crystals of menthol. Experience has shown, however, that oil of the best quality did not respond to this test, which was, therefore, omitted in the last revision. The assay for menthol (acetylization test) and of methyl acetate (saponification test) will be given under volumetric analysis.

Medical Properties.—Carminative and flavor. Administered as *spirit,* U.S.P. (p. 182). The oil is a constituent of *peppermint water,* U.S.P. (p. 177).

Dose.—0.2 mil (3 minims).

MENTHA VIRIDIS—Spearmint

(Menth. Vir.)

The dried leaves and flowering tops of *Mentha spicata* Linné (*Mentha viridis* Linné) (Fam. *Labiatæ*).

OLEUM MENTHÆ VIRIDIS—Oil of Spearmint

(Ol. Menth. Vir.—Spearmint Oil)

A volatile oil distilled from the flowering plant of *Mentha spicata* Linné (*Mentha viridis* Linné) (Fam. *Labiatæ*), and yielding not less than 43 per cent. by volume, of carvone [$C_{10}H_{14}O = 150.11$]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, yellow or greenish-yellow liquid; characteristic odor and taste; soluble in 1 volume of 80 per cent. alcohol; sp. gr. 0.917 to 0.934; optical rotation −38° to −55° in 100-mm. tube. For details see U.S.P., p. 296.

Assay.—Like oil of caraway.

Composition.—Levogyre carvone, 66 per cent.; limonene, phellandrene, dihydrocarvenone.

Medical Propreties.—Like oil of peppermint and in same dose.

Spirit of Spearmint. U.S.P. (p. 182), is made from the oil and a small amount of the herb.

Peppermint, and spearmint, are representatives of the *Labiatæ*, the "lip family," or mint family; this group of plants being so called because the flowers of this family have their petals united with a two-lipped corolla, as shown in (Fig. 243), the flower of the horsemint.

The plants of this family are characterized by the presence of aromatic volatile oils, and a large number of them are used in medicine. Among those formerly official may be cited *pennyroyal, scullcap, boneset, melissa* (Balm), *catnip, thyme,* and *origanum.*

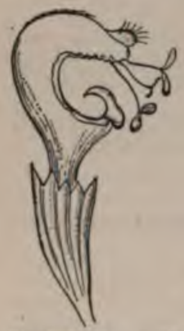


Fig. 243.—Horsemint flower.

CARYOPHYLLUS—Clove

(**Caryoph.**—Cloves)

The dried flower-buds of *Eugenia aromatica* (Linné) O. Kuntze *Jambosa Caryophyllus* (Sprengel) Niedenzu (Fam. *Myrtaceæ*), without the presence or admixture of more than 5 per cent. of the peduncles, stems and other foreign matter.

Constituents.—Volatile oil, tannin, gum resin, fixed oil.

Remarks.—Cloves are not fruit nor seed, as is commonly believed, but are flower-buds. Sliced lengthwise, the sample is found hollow in the upper parts, where will be found the stamens, which look like dried threads. Cloves are used as a spice, and are largely adulterated. For instance, whole cloves from which the oil has been distilled have been put on the market. These are detected by the fact that such exhausted cloves float horizontally on the surface of water, while the true article, containing the heavy volatile oil, will either sink or float in an upright position. The powder is adulterated with starchy material or with mineral substances, which impurities can be detected by the fact that pure powdered cloves, when viewed under the microscope, contain few or no starch-grains, no "stone-cells" (as does ground cocoanut shell, another adulterant), and yield, on burning, no more than 8 per cent. of ash.

Clove is used in the following official preparations: *Compound tincture of lavender* and *aromatic tincture of rhubarb.*

Dose.—250 milligrammes (4 grains).

OLEUM CARYOPHYLLI—Oil of Clove

(**Ol. Caryoph.**—Clove Oil—Oil of Cloves)

A volatile oil distilled from the flower-buds of *Eugenia Aromatica* (Linné) O. Kuntze *Jambosa Caryophyllus* (Sprengel) Niedenzu (Fam. *Myrtaceæ*), and yielding not less than 82 per cent. by volume of eugenol [$C_{10}H_{12}O_2$ = 164.10]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, or pale yellow liquid, darkens and thickens on age and on exposure to the air; characteristic odor and taste; soluble in 2 volumes of 70 per cent. alcohol; sp. gr. 1.038 to 1.060; optical rotation, not more than $-1° 10'$ in 100-mm. tube. For details see U.S.P., p. 289.

For *tests for identity*, for *impurities:* Phenol (aqueous solution not colored blue or violet with ferric chloride). See U.S.P., p. 289.

Outline of Assay.—The oil is shaken with potassium hydroxide solution in a cassia flask; the flask is filled to the graduations with the alkaline solution and the volume of the insoluble portion is read. For details see U.S.P., p. 289.

Composition.—Eugenol (80 to 92 per cent.); a number of alcohols (methyl, methylamyl, furfuryl, benzyl, etc.); a number of ketones (acetone, methyl-amyl ketone, etc.); several aldehydes (dimethyl-furyl-aldehyde, etc.); esters (methyl salicylate, etc.); and caryophyllene.

Remarks.—The assay given above is based on the same principle as that of oil of thyme (p. 743), namely, dissolving of the phenol in alkaline solution and measuring the residual liquid.

Medical Properties.—Stimulant. Used in toothache.

Dose.—0.2 mil (2 minims).

ANISUM—Anise

(Anis.—Aniseed)

The dried ripe fruit of *Pimpinella Anisum* Linné (Fam. *Umbelliferæ*) without the presence or admixture of more than 3 per cent. of foreign seeds and other vegetable matter.

Consttuents—Volatile oil, fixed oil, carbohydrates, proteins, etc.

Remarks.—The pharmacopœia directs that anise, when triturated with potassium hydroxide solution, should not give a mouse-like odor. This test is to distinguish it from the poisonous conium (p. 835), which closely resembles anise in appearance.

Medical Properties.—Carminative, stimulant, flavor.

Dose.—500 milligrammes (8 grains).

Illicium, or star anise, the fruit of *Illicium verum*, was official in the pharmacopœia of 1890, and is here mentioned because it yields an oil identical with that from anise.

OLEUM ANISI—Oil of Anise—Oil of Star Anise

(Ol. Anisi.—Anise Oil)

A volatile oil distilled from the ripe fruit of *Pimpinella Anisum* Linné (Fam. *Umbelliferæ*) or from the ripe fruit of *Illicium verum* Hooker filius (Fam. *Magnoliaceæ*). The botanical source from which it is derived must be stated on the label. If solid material has separated, carefully warm the Oil until liquefied, and thoroughly mix it before dispensing. Preserve it in well-stoppered, amber-colored bottles, protected from light.

Summarized Description.

Colorless or pale yellow strongly refractive liquid; characteristic odor and taste; soluble in 3 volumes of 90 per cent. alcohol; sp. gr. 0.978 to 0.988; refractive index, 1.544 to 1.560; congealing point, not less than 15°C. For details see U.S.P., p. 287.

For *tests for identity*, for *impurities:* Oil of fennel (oil is lævorotary). Phenols (alcoholic solution not colored blue or brown by ferric chloride). Heavy metals (hydrogen sulphide test see U.S.P., p. 287 and also Part V of this book.

Composition.—Anethol, 80 to 90 per cent.; methyl-chavicol, both $C_{10}H_{12}O$.

Remarks.—As anethol is a solid, the congealing point of the oil (15°C.) is a criterion of value.

Medical Properties.—Carminative and flavor. Used in making *anise water* (p. 174) and *spirit of anise* (p. 180). It is also a constituent of *paregoric* (p. 230).

Dose.—0.2 mil (3 minims).

CORIANDRUM—Coriander

(Coriand.—Coriander Seed)

The dried ripe fruits of *Coriandrum sativum* Linné (Fam. *Umbelliferæ*), without the presence or admixture of more than 5 per cent. of other fruits, seeds, or foreign matter.

Constituents.—Volatile oil, ¼ to ½ per cent.; fixed oil, etc.

Medical Properties.—Aromatic, carminative.

Dose.—500 milligrammes (8 grains).

OLEUM CORIANDRI—Oil of Coriander

(Ol. Coriand.—Coriander Oil)

A volatile oil distilled from the ripe fruit of *Coriandrum sativum* Linné (Fam. *Umbelliferæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid, characteristic odor and taste; soluble in 3 volumes of 70 per cent. alcohol; sp. gr. 0.863 to 0.875; optical rotation, +8° to +13° in 100-mm. tube. For details see U.S.P., p. 291.

Composition.—Pinene, cymene and other terpenes: d-linalool, geraniol, l-borneol and their acetic esters; decylic alcohol.

Medical Properties.—Carminative. A constituent of *syrup of senna* (p. 200).

Dose.—0.2 mil (3 minims).

FŒNICULUM—Fennel

(Fœnic.—Fennel Seed)

The dried, ripe fruits of cultivated varieties of *Fœniculum vulgare* Miller (Fam. *Umbelliferæ*), without the presence or admixture of more than 4 per cent. of foreign matter.

Constituents.—Volatile oil, 2 to 4 per cent.; fixed oil, etc.

Medical Properties.—Carminative, stimulant. A constituent of compound infusion of senna (p. 217).

Dose.—1 gramme (15 grains).

OLEUM FŒNICULI—Oil of Fennel

(Ol. Fœnic.—Fennel Oil)

A volatile oil distilled from the ripe fruit collected from cultivated varieties of *Fœniculum vulgare* Miller (Fam. *Umbelliferæ*). If wholly or partly solidified, carefully warm the Oil until liquefied and thoroughly mix it before dispensing. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid; characteristic odor and taste; soluble in 8 volumes of 80 per cent. alcohol and 1 volume of 90 per cent. alcohol; sp. gr. 0.953 to 0.973; optical rotation, +12° to +24° in 100-mm. tube. For details see U.S.P., p. 292.

Congealing Point.—At least 3°C. Details as given under Oil of Anise, except that oil is to be chilled to −0°C.

Composition.—*Anethol,* 50 to 60 per cent.; *fenchone,* a ketone having formula $C_{10}H_{16}O$; pinene; dipentene; etc.

Medical Properties.—Carminative. Very popular among German physicians as a constituent of digestive powders. It is a constituent of *compound licorice powder* (p. 293) and of *compound spirit of juniper* (p. 181).

Dose.—0.2 mil (3 minims).

CARUM—Caraway

(Caraway Seed)

The dried fruits of *Carum Carvi* Linné (Fam. *Umbelliferæ*). Without the presence or admixture of more than 3 per cent. of other fruits, seeds or foreign matter. Preserve Caraway in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Volatile oil, 5 per cent.; fixed oil; resin.

Medical Properties.—Carminative, stimulant, flavor.

Dose.—1 gramme (15 grains).

OLEUM CARI—Oil of Caraway

(Ol. Cari—Caraway Oil)

A volatile oil distilled from the fruit of *Carum Carvi* Linné (Fam. *Umbelliferæ*), and yielding not less than 50 per cent., by volume, of carvone [$C_{10}H_{14}O = 150.11$]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid; characteristic odor and taste; soluble in 8 volumes of 80 per cent. alcohol; sp. gr. 0.900 to 0.910; optical rotation, +70° to +80° in 100-mm. tube. For details see U.S.P., p. 289.

Outline of Assay.—Shake the oil in a cassia flask with a carefully neutralized saturated solution of sodium sulphite, heat mixture on a water-bath, then cool, fill the flask to the graduations with the sulphite solution and read the volume of the undissolved oil.

Composition.—Carvone, 50 to 60 per cent.; dextrogyrate limonene; etc.

Remarks.—It will be seen above that the pharmacopœia gives an assay of the carvone content of this oil. This assay is based upon the solubility of this ketone in a solution of sodium sulphite; that chemical forming water-soluble compounds with aldehydes and ketones. When 10 mils of the oil is warmed with the sulphite solution, all of the carvone is dissolved leaving the other constituents of the oil floating on top as an insoluble layer. As carvone should constitute 50 per cent. of the bulk of the oil, the insoluble residue from 10 mils, should measure not more than 5 mils. The operation is carried out in a *cassia flask* (Fig. 244).

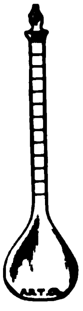


Fig. 244.—Cassia Flask.

The same method is employed in determining the cinnamic aldehyde content of oil of cinnamon (p. 745) and the carvone content of oil of spearmint (p. 748).

Medical Properties.—Carminative. A constituent of *compound spirit of juniper* (p. 181).

Dose.—0.2 mil (3 minims).

PETROSELINUM—Parsley Fruit

(Petrosel.—Parsley Seed)

The dried ripe fruit of *Petroselinum sativum* Hoffman (Fam. *Umbelliferæ*), without the presence or admixture of more than 5 per cent. of foreign seeds or other matter. Preserve Parsley Fruit carefully in tightly closed containers, protected from light.

Constituents.—Volatile oil (1.4 per cent.); fixed oil (22 per cent.); pectin; chlorophyll; tannin; *apiol* (p. 722).

Remarks.—This drug was introduced into the present pharmacopœia, since it is used to make the oleoresin.

Medical Properties.—Emmenagogue.

Dose.—No dose is given in the pharmacopœia, since the oleoresin is used almost exclusively. The fruit can, however, be administered in 15-grain doses.

Parsley root is described in the National Formulary and a recipe for its fluidextract is also given (p. 250).

The drugs last studied—anise, fennel, coriander, caraway and parsley—are representatives of the Umbelliferæ; the parsley family, whose flowers are arranged on stalks which radiate like rods of an umbrella, as shown in Fig. 245.

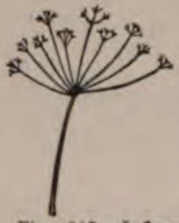


Fig. 245.—Inflorescence of umbellifera (schematic).

Most official drugs yielded by the Umbelliferæ are fruit, which are, unfortunately, commonly called "seeds."

A fruit can vary from a seed, with its dry ovary wall, to very elaborate fruit, which include several other organs attached to the ovary. Thus, when we examine an apple, we find three distinct layers—the red skin, the white meat, and the papery core surrounding the seed. Of these layers, only the core represents the ovary wall, the meat and skin being a modification of another part of the flower—the green calyx. On the other hand, an acorn likewise represents a true fruit, the cup being a cluster of leaves at the base of the ripened ovary, the latter being the "nut." From this can be separated the outer coat, which represents the ovary wall, while the "kernel" within, with its shaggy coat, represents the seed. Similarly, the so-called "seeds"—*anise, caraway, coriander*, and *fennel*—are fruit just as are apples and acorns, and, like the acorn, the ovary wall is inconsiderable, and does not separate from the seed of its own free will.

Pimenta (U.S.P. VIII; N.F. IV), or *allspice*, is the dried, nearly ripe fruit of *Pimenta officinalis* Lindley (Fam. *Myrtaceæ*.) It contains volatile oil, resin, fixed oil, chlorophyll and traces of alkaloid. It is used as a stomachic and carminative in 15-grain doses.

OLEUM PIMENTÆ—Oil of Pimenta

(Ol. Piment.—Pimento Oil—Oil of Allspice)

A volatile oil distilled from the fruit of *Pimenta officinalis* Lindley (Fam. *Myrtaceæ*), yielding not less than 65 per cent., by volume, of eugenol [$C_{10}H_{12}O_2 = 164.10$]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, yellow or reddish liquid, darkens on age; characteristic odor and taste; soluble in 1 volume of 90 per cent. alcohol and in 2 volumes of 70 per cent. alcohol; sp. gr. 1.018 to 1.048; optical rotation, 0° to −4° in 100-mm. tube. For details see U.S.P., p. 299.

Assay.—Like that of oil of clove.

Constituents.—Eugenol, sesquiterpenes, etc.
Medical Properties.—Carminative and flavor.
Dose.—0.2 mil (3 minims).

CARDAMOMI SEMEN—Cardamom Seed

(**Cardam. Sem.**—Cardamomum, U.S.P. VIII)

The dried seeds of *Elettaria Cardamomum* White et Maton (Fam. *Zingiberaceæ*), recently removed from the capsules.

Constituents.—Volatile oil, fixed oil, starch, etc. The volatile oil consists of terpenes (dipentene and terpene), terpineol, cineol, terpinyl acetate.

Remarks.—While former pharmacopœias recognized the entire fruit of cardamom, including the pericarp (or "hulls") the present pharmacopœia directs the use of seed only. Like all drugs used in spices, the commercial powder is apt to be adulterated with mineral matter, hence the pharmacopœia directs that it should yield not more than 4 per cent. of ash.

Medical Properties.—Carminative, stomachic. Official preparations: The *tincture* (p. 225) and the *compound tincture* (p. 225). Also used in *compound tincture of gentian* (p. 227), *tincture of rhubarb* (p. 232), and *aromatic powder* (p. 291).

Dose.—1 gramme (15 grains).

SABAL—Sabal

(Saw Palmetto Berries)

The partially dried, ripe fruit of *Serenoa serrulata* (Michaux) Hooker filius (Fam. *Palmæ*). Preserve Sabal in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Volatile oil (only from fresh fruit), 1.3 per cent.; fixed oil (ethyl ethers of caproic, caprylic, oleic, and other acids), about 1.6 per cent.; sugar (pentoses), 5.4 per cent. The presence of an alkaloid is a subject of dispute.

The so-called "volatile oil" is merely an ethyl ester of the various fatty acids found in the fruit. It is noted only in alcoholic galenicals of the drug.

Remarks.—As apparently the only really active constituent is volatile oil, the use of the partly dried fruit seems of no service. Several large manufacturers prepare the fluidextract from *fresh fruit.*

Medical Properties.—Supposedly tonic and stimulant, especially to the reproductive organs. Reputation chiefly due to advertising by nostrum makers. The *fluidextract* (p. 244) is official.

Dose.—1 gramme (15 grains).

AURANTII AMARI CORTEX—Bitter Orange Peel

(**Aurant. Amar. Cort.**)

The dried rind of the fruit of *Citrus Aurantium amara* Linné (Fam. *Rutaceæ*).

Constituents.—Volatile oil; *hesperidin;* an acid, $C_{44}H_{28}O_{14}$; resin; *aurantiamarin,* a bitter glucoside. The volatile oil is chemically identical with that of sweet orange, except that it has a bitter taste, due to the aurantiamarin it contains. This oil is not official.

Medical Properties.—Aromatic bitter. Official preparations, the tincture (p. 223) and the fluidextract (p. 246), in *compound tincture of cinchona* (p. 226) and *compound tincture of gentian* (p. 227).

Dose.—1 gramme (15 grains).

AURANTII DULCIS CORTEX—Sweet Orange Peel

(Aurant. Dulc. Cort.)

The outer rind of the fresh, ripe fruit of *Citrus Aurantium sinensis* Gallesio (Fam. *Rutaceæ*).

Constituents. Volatile oil; *hesperidin,* $C_{22}H_{26}O_{12}$, a glucoside that hydrolyzes to *hesperetin,* $C_{16}H_{14}O_6$.

Remarks.—Note that the pharmacopœia directs the use of the outer rind—that is, the thin yellow layer must be separated from the thick white layer (the *zest*). This is important in making pharmaceuticals, since the zest contains a body that blackens with iron salts, and the same will be true of preparations made from the peel not freed from the zest. It is used in *tincture of sweet orange* (p. 223).

OLEUM AURANTII—Oil of Orange

(Ol. Aurant.—Oleum Aurantii Corticis, U.S.P. VIII—Orange Oil—Oil of Sweet Orange)

A volatile oil obtained by expression from the fresh peel of sweet orange, *Citrus Aurantium sinensis* Gallesio (Fam. *Rutaceæ*), and its varieties. Preserve it in small, well-stoppered, amber-colored bottles, in a cool place, protected from light. Oil of Orange having a terebinthinate odor is not to be dispensed.

Summarized Description.

Yellow liquid; characteristic odor and taste; sp. gr. 0.842 to 0.846; refractive index, 1.4728 to 1.4737; optical rotation, not less than + 94° in 100-mm. tube; first 5 mils of distillate from 50 mils of oil should have almost the same refraction and rotation as the original oil. For details see U.S.P., p. 287.

Composition.—Dextrogyrate limonene, 90 per cent.; *citral,* derivative of anhydrogeraniol (p. 732); citronellal; methyl *anthranilate* esters, etc.

Remarks.—As already mentioned (p. 728), the reason why oil of orange and of lemon become terebinthinate is through the conversion of their limonene into dipentene. This change, of course, ruins the quality of the oil, and it is poor pharmacy to use such oils in preparations. Of the several schemes suggested to prevent this decomposition, the best is the adding of a small amount of glycerin—say, half an ounce to four ounces of oil—and keeping bottle inverted. In this way the mouth of the bottle is "sealed" with a layer of the glycerin, which prevents access of air. When the oil is to be used, the bottle is placed in an upright position for a few minutes, and the oil decanted from the heavier glycerin layer. This, in the writer's experience, proved more satisfactory than diluting the oil with alcohol. Cottonseed oil or olive oil may be substituted for glycerin in this method. The commercial oil is likely to be adulterated with oil of turpentine or with the terpenes obtained from oil of lemon, after preparation of terpeneless oil (p. 729). The polariscopic and refraction readings of the first distillation fraction of the oil outline above will detect these sophistications.

Medical Properties.—Flavor. It is a constituent of *compound spirit of orange* (p. 180).

Dose.—0.2 mil (3 minims).

LIMONIS CORTEX—Lemon Peel

(Limon. Cort.)

The outer rind of the fresh ripe fruit of *Citrus medica Limonum* (Risso) Hooker filius (Fam. *Rutaceæ*).

Constituents.—Volatile oil; hesperidin, etc.

Remarks.—It will be noted that this drug, like orange peel, is the "outer rind" separated from the zest (p. 754).

Medical Properties.—Flavor. Official preparation, *tincture of lemon peel*, p. 229.

OLEUM LIMONIS—Oil of Lemon

(Ol. Limon—Lemon Oil)

A volatile oil obtained by expression from the fresh peel of the ripe fruit of *Citrus medica Limonum* (Risso) Hooker filius (Fam. *Rutaceæ*), and yielding not less than 4 per cent. of the aldehydes from Oil of Lemon calculated as citral [$C_{10}H_{16}O$ = 152.13]. Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light. Oil of Lemon having a terebinthinate odor is not to be dispensed.

Summarized Description.

Pale yellow or greenish-yellow liquid, characteristic odor and taste; sp. gr. 0.851 to 0.855; refractive index, 1.4744 to 1.4755; optical rotation, +57° to +64° in 100-mm. tube; first part of distillate (see oil of orange) should have almost same refraction and rotation as the original oil. For details see U.S.P., p. 294.

Composition.—Dextrogyrate limonene, 90 per cent.; phellandrene; α-pinene; l-camphene, terpinene; sesquiterpenes; citral 7 to 10 per cent.; citronellal; esters, etc.

Remarks.—It will be noticed that while it is claimed that oil of lemon contains 7 to 10 per cent. citral, the pharmacopœia demands not less than 4 per cent. The pharmacopœial assay will be considered in the chapter on Volumetric Analysis.

Medical Properties.—Flavoring. Used in *aromatic spirit of ammonia*, U.S.P. (p. 457) and *compound spirit of orange*, U.S.P. (p. 180). *Spirit of lemon*, U.S.P. 1890, has been replaced by tincture of lemon peel.

Dose.—Of the oil, 0.2 mil (3 minims).

Oil of bergamot, U.S.P. 1890, is obtained by expression of the rind of the bergamot orange, the fruit of *Citrus Bergamia*. Its green color is due to the presence of copper from its container. It is used as a perfume.

Oil of neroli, U.S.P. 1890, is the oil obtained by distillation of orange flowers, and is a by-product in the manufacture of orange flower water. It is used in perfumery.

It will be noted that the three oils—orange, lemon, and bergamot—are obtained by expression (as already described on p. 739) of the rind of closely allied fruits; that this group of fruit—orange, lemon, lime, etc.—forms a subdivision of the plant family, Rutaceæ.

MYRISTICA—Myristica

(Myrist.—Nutmeg)

The ripe seeds of *Myristica fragrans* Houttuyn (Fam. *Myristicaceæ*), deprived of the arilli and seed-coats. Preserve the kernels in tightly closed containers, adding a few drops of carbon tetrachloride or chloroform from time to time to prevent attack by insects. Reject broken or wormy kernels.

Constituents.—Volatile oil, about 7 per cent.; fat, about 25 per cent.; starch, etc. Power and Salway have shown that the fat, called *nutmeg butter*, or *oil of mace*, and obtained by expressing nutmeg between hot plates, contains about 12.5 per cent. of the essential oil; about 73 per cent. of the trimyristicin (glyceryl myristate) and small amounts of other fatty acids.

Medical Properties.—Stimulant, stomachic, flavor. Used in *compound tincture of lavender* (p. 229), *aromatic tincture of rhubarb* (p. 232), and *aromatic powder* (p. 291).

Dose.—500 milligrammes (8 grains).

OLEUM MYRISTICÆ—Oil of Myristica

(Ol. Myrist.—Myristica Oil—Oil of Nutmeg)

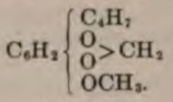
A volatile oil distilled from the kernel of the ripe seed of *Myristica fragrans* Houttuyn (Fam. *Myristicaceæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless or pale yellow liquid; characteristic odor and taste; soluble in 1 volume of alcohol and in 3 volumes of 90 per cent. alcohol; sp. gr. 0.859 to 0.924; optical rotation, +12° to +30° in 100-mm. tube; on evaporation not more than 2 per cent. of residue is left. For details see U.S.P., p. 297.

Constituents.—Eugenol; terpenes (pinene, camphene, dipentene, etc.); alcohols (linalool, borneol, terpineol, etc.); *myristicin*; acids (myristic, formic, acetic, etc.).

Composition.—Myristicin has the graphic formula:



$$C_6H_2\left\{\begin{array}{l} C_4H_7 \\ {}^{O}_{O}\!>CH_2 \\ OCH_3. \end{array}\right.$$

and is the narcotic constituent of nutmeg.

Medical Properties.—Flavor. A constituent of *aromatic spirit of ammonia* (p. 454).

Dose.—0.2 mil (3 minims).

Macis (U.S.P. 1890; N.F. IV), or *mace*, is the arilloid of the nutmeg. It yields a volatile oil practically identical with that of nutmeg, and, like it, is used as a spice.

An "arilloid," or "arillus," as an outgrowth from the base of the testa or seed-coat. The testa of different seeds vary widely in appearance, thus the testa of the almond is not the "shell" of the almond, for the shell is the inner layer of the ovary wall and is a part of the fruit. The almond testa is the thin brown scurfy coating which can be removed from the seed by soaking in warm water.

In other seeds the testa is hard and brittle. Thus cocoanut is a huge seed, and its shell a testa. In myristica the testa is thin and brittle, is loose, and can be easily removed, and the official nutmeg is the kernel of the seed freed from this brittle testa, while mace is the arilloid which branches irregularly over the testa of the unbroken seed. Mace is given as a carminative in 8-grain doses.

DRUGS CONTAINING VOLATILE OIL AND RESIN

This class of drugs differs from the volatile oil drugs just considered by the prominence of their resin content. It will be noted that most of the volatile oil drugs just considered contained resinous matter, but these resins were either insignificant as to amount or indifferent as to activity. On the other hand, the drugs now to be considered owe their activity as much to the resin they contain as to their volatile oil, and it will be noted that all the drugs furnishing official pharmaceutic oleoresins (p. 253) are here considered. As to the chemistry of the resinous ingredients of this class of drugs, let it be said that a general consideration of that little understood class of bodies—the resins—is reserved for a special chapter (Chapter XLVIII), which, perhaps, would be the better place to consider drugs of the class under consideration. However, since these drugs are most prominently characterized by their odor, and this is largely due to the volatile oil they contain, it is well to consider them among the volatile oil drugs. It might be stated that all these resinous drugs should be extracted with stronger alcohol.

STILLINGIA—Stillingia

(Stilling.—Queen's Root)

The dried roots of *Stillingia sylvatica* Linné (Fam. *Euphorbiaceæ*). Preserve Stillingia in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Volatile oil; resins; *stillingine*, an alkaloid, fixed oil; etc.

One of the resins is the combination of a phytosterol with fatty acids (acetic, butyric, valeric, angelic, oleic, etc.). From the other resin was isolated a phytosterolin, $C_{33}H_{56}O_6$, vanillin, umbelliferon, vanillic and other acids.

Medical Properties.—Nauseant, emetic, in small doses. More or less laxative. *Fluidextract* official (p. 244).

Dose.—2 grammes (30 grains).

SUMBUL—Sumbul

(Musk-root)

The rhizome and roots of *Ferula Sumbul* (Kauffmann) Hooker filius (Fam. *Umbelliferæ*).

Constituents.—Two balsamic resins; trace volatile oil; a glucoside of *umbelliferon*, etc.

Medical Properties.—Nerve stimulant. The *extract* (p. 280) and the *fluidextract* (p. 244) are official.

Dose.—2 grammes (30 grains).

ASPIDIUM—Aspidium

(Male Fern)

The rhizome and stipes of *Dryopteris Filix-mas* (Linné) Schott, or of *Dryopteris marginalis* (Linné) Asa Gray (Fam. *Polypodiaceæ*), collected in the autumn, freed from the roots and dead portions of rhizome and stipes and dried at a temperature not exceeding 70°C. Preserve Aspidium in tightly closed containers and protected from light.

Constituents.—Volatile oil; fixed oil; resin; *filicic acid* which is dibutyryl-phloroglucin, *tannaspidic acid; pteritannic acid; felix red,* etc. The volatile oil consists of the hexyl and octyl esters of the fatty acids (butyric, etc.), also free fatty acids.

Remarks.—Characteristic for good quality of this drug is its green color, which fades as the drug becomes old and worthless, hence the pharmacist should use only such samples as are still green.

Medical Properties.—Tapeworm expeller. Used almost entirely in the form of the *oleoresin*, U.S.P. (p. 254).
Dose.—Of drug, 4 grammes (60 grains).

ZINGIBER—Ginger

(Zingib.)

The dried rhizomes of *Zingiber officinale* Roscoe (Fam. *Zingiberaceæ*), the outer cortical layers of which are often either partially or completely removed. Preserve it in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Volatile oil; resin, etc.

The volatile oil contains sesquiterpenes, terpenes, citral, methyl-heptanone, nonylaldehyde, linalool, d-borneol, acetic and caprylic acid esters, chavicol, cineol and a characteristic alcohol *zingiberol*, $C_{15}H_{25}OH$. The resin consists of three distinct resins, and when fused with sodium hydroxide, yields protocatechuic acid.

Remarks.—The best quality of ginger comes from Jamaica, and occurs in handsome lobed pieces coated white with lime. Preserved ginger is the same root collected in the spring when green and succulent and boiled with syrup.
Medical Properties.—Carminative, stimulant, flavor. Official preparations: *Oleoresin* (p. 255), *tincture* (p. 234), and *fluidextract* (p. 244). The last is used in making the *syrup*. Powdered ginger is a constituent of *aromatic powder* (p. 291).
Dose.—Of drug, 1 gramme (15 grains).

Calamus (U.S.P. VIII), or *sweet flag*, is the unpeeled, dried rhizome of *Acorus Calamus* Linné (Fam. *Araceæ*). It contains volatile oil, resin, *acorin*, *calamine* and starch.
The *volatile oil* consists of pinene, a sesquiterpene, fatty acids (acetic, heptylic, palmitic, etc.), eugenol, asarone and asaryl aldehyde, and calamus camphor, or calameone, $C_{15}H_{26}O_2$, which has a structure resembling cineol.
Acorin is a bitter glucoside that hydrolyzes to glucose and a terpene and which oxidizes to *acoretin*.
Calamus is used as a carminative, stimulant, and flavor. The whole peeled root is used for teething infants to chew upon. *Dose*, 15 grains.

CIMICIFUGA—Cimicifuga

(Cimicif.—Black Cohosh—Black Snakeroot—Macrotys)

The dried rhizome and roots of *Cimicifuga racemosa* (Linné) Nuttall (Fam. *Ranunculaceæ*), without admixture of more than 2 per cent. of stems and foreign matter.

Constituents.—Acids (oleic, palmitic, isoferulaic, etc.); sugar; tannin; phytosterols, trace of alkaloid, etc.
Medical Properties.—Tonic and "blood purifier" in domestic practice.
Dose.—1 gramme (15 grains).

SERPENTARIA—Serpentaria

(Serpent.—Texas Snakeroot—Virginia Snakeroot)

The dried rhizome and roots of *Aristolochia Serpentaria* Linné, known in commerce as Virginia Snakeroot, or of *Aristolochia reticulata* Nuttall, known in commerce as Texas Snakeroot (Fam. *Aristolochiaceæ*), without the presence or admixture of more than 10 per cent. of the stems or other foreign matter.

Constituents.—Volatile oil; bitter principle, similar to quassin; resin, *aristolochine.*

The volatile oil consists chiefly of borneol, the Texas snakeroot containing also pinene.

Remarks.—It will be observed that official serpentaria is derived from two different plants, the drugs, however, being practically identical in medicinal action.

Medical Properties.—Popular tonic and "blood purifier." The drug is a constituent of *compound tincture of cinchona* (p. 226).

Dose.—1 gramme (15 grains).

XANTHOXYLUM—Xanthoxylum

(Xanthox.—Prickly Ash Bark)

The dried bark of *Xanthoxylum americanum* Miller, known in commerce as Northern Prickly Ash Bark, or *Xanthoxylum Clava-Herculis* Linné, known in commerce as Southern Prickly Ash Bark (Fam. *Rutaceæ*).

Constituents.—Volatile oil, resin, a bitter principle, *xanthoxylin;* berberin. Xanthoxylin from northern prickly ash is $C_{15}H_{14}O_4$, while that from the southern is $C_{14}H_{12}O_4$.

Remarks.—As in the case of serpentaria, two different plants yield official prickly ash. The constituents of the two barks are practically identical, although it is said that the bitter principle (xanthoxylin) from the two is not exactly the same.

The curious name, xanthoxylum, has a distinct and sensible meaning, and the best way in which to present the matter forcibly is to mention three drugs between whose names there exists a similarity.

These are:

Xanthoxylum, from the Greek "*xanthos,*" yellow, and "*xylon,*" wood, or yellow wood.

Erythroxylon, from the Greek "*erythros,*" red, and "*xylon,*" wood, or red wood.

Hæmatoxylon, from the Greek "*haima,*" the blood, and "*xylon,*" wood, or blood wood.

Medical Properties.—Alterative, diuretic, sialagogue. Administered as *fluidextract* (p. 244).

Dose.—2 grammes (30 grains)

MEZEREUM—Mezereum

(Mezereon)

The dried bark of *Daphne Mezereum* Linné, *Daphne Gnidium* Linné, or of *Daphne Laureola* Linné (Fam. *Thymeleaceæ*).

Constituents.—Acrid resin; wax; daphnin; starch, gum, acids, etc. Daphnin is a glucoside that hydrolyzes to daphnetin.

Medical Properties.—Irritant, sialagogue, externally as a rubefacient. The drug is a constituent of *compound fluidextract of sarsaparilla* (p. 247).

Matico (U.S.P. VIII; N.F. IV) represent the dried leaves of *Piper angustifolium* Ruiz and Pavon (Fam. *Piperaceæ*). It contains volatile oil, resin, tannin.

The *volatile oil* consists of terpenes, sesquiterpenes, cineol and phenol ethers (asarone, etc.). As the commercial oil is distilled from leaves of different species of *Piper*, its composition is quite variable. Matico is used as a vulnerary and styptic. Its dose, when taken internally is 60 grams.

ERIODICTYON—Eriodicyton

(**Eriodict.**—Yerba Santa)

The dried leaves of *Eriodictyon californicum* (Hooker and Arnott) Greene (Fam. *Hydrophyllaceæ*), without the presence or admixture of more than 5 per cent. of stems or other foreign matter.

Constituents.—Resins, trace of volatile oil, tannin, eriodictyol (a phenol), $C_{15}H_{12}O_6$, homo-eriodictyol (a phenol, $C_{16}H_{14}O_6$ and isomeric with hesperetin), 3 per cent.

Medical Properties.—Expectorant. Chiefly used for masking taste of quinine, the *aromatic elixir of yerba santa,* N.F. (p. 207), and the *aromatic syrup of yerba santa,* N.F. (p. 202), being generally employed for this purpose. These are prepared from the official *fluidextract* (p. 244).

Dose.—1 gramme (15 grains).

GRINDELIA—Grindelia

(Grindel.)

The dried leaves and flowering tops of *Grindelia camporum* Greene, or *Grindelia cuneifolia* Nuttall, or *Grindelia squarrosa* (Pursh) Dunal (Fam. *Compositæ*), without the presence or admixture of more than 10 per cent. of stems and other foreign matter.

Constituents.—Volatile oil, fatty acids (formic, cerotic, palmitic, etc.) free and as glyceryl esters; a phytosterol, melting at 166°C.; an alcohol $C_{17}H_{28}O_3$, melting at 256°; a phenol $C_{14}H_{12}O_5$, melting at 227°; glucose, tannin, etc.

Medical Properties.—Recommended for asthma. The official *fluidextract* (p. 244) is also used externally as a lotion in the eruption caused by poison oak.

Dose.—2 grammes (30 grains).

Sabina (U.S.P. VIII), or *savine,* is composed of the tops of *Juniperus Sabina* Linné (Fam. *Coniferæ*). It contains volatile oil, and resin. The natural order Coniferæ, to which the savine tree belongs, is commonly called the pine family and yields many important products, as turpentine and Canada turpentine. Savin represents leafy tops, which are the ends of the branches, hence the youngest and freshest part of the trees. It is used as an emmenagogue in 8-grain doses.

Oleum Sabinæ (U.S.P. VIII), or *oil of savine,* is distilled from the fresh tops of savine. It contains *sabinol,* $C_{10}H_{16}O$ (partly as acetic acid ester); *cadinene* and possibly some terpenes. It is used like the drug in 1-minim doses.

CANNABIS—Cannabis

(**Cannab.**—Cannabis Indica, U.S.P.VIII. Guaza, Ganjah)

The dried flowering tops of the pistillate plants of *Cannabis sativa* Linné, or of the variety *indica* Lamarck (Fam. *Moraceæ*), freed from the thicker stems and large foliage leaves and without the presence or admixture of more than 10 per cent. of fruits or other foreign matter. Cannabis, made into a fluidextract in which *one hundred mils* represent *one hundred grammes* of the drug when assayed biologically, produces incoördination when administered to dogs in a dose of not more than 0.03 mil of fluidextract per kilogramme of body weight.

Constituents.—Volatile oil; resin; bitter substance; *cannabine,* an alkaloid.

The *volatile oil* is said by Personne to contain *cannabene,* $C_{18}H_{20}$, while other writers claim it consists of sesquiterpenes. The *resin* called *cannabin* is a mixture, the active ingredient of which is a red oily mixture called *cannabinol*.

Remarks.—It is of interest that while the plant yielding this drug is identical with the American hemp, the latter plant is of little value in medicine, since it contains only a small amount of resin. Houghton, however, claims that the American hemp is as active as the Indian if only properly prepared. Marshall claims that the deterioration of the drug is due to the oxidization of cannabinol and that such deterioration can be prevented by keeping the drug hermetically sealed.

Medical Properties.—Powerful nervous stimulant, the resinous extract being used in the far East by smoking, under the name of *hashish*. The *extract*, U.S.P. (p. 274), is largely used to relieve the pain of corns, a favorite recipe for this purpose being *compound salicylic collodion*, N.F. (p. 214). The *tincture* (p. 224) and the *fluidextract* (p. 244) are also official.

Dose.—Of drug, 60 milligrammes (1 grain).

CAPSICUM—Capsicum

(**Capsic.**—Cayenne Pepper—African chillies)

The dried ripe fruits of *Capsicum frutescens* Linné (Fam. *Solanaceæ*), without the presence or admixture of more than 2 per cent. of stems and calyxes and other foreign matter.

Constituents.—Volatile oil (trace); resin; fat, *capsaicin*. The oleoresin consists of two oily liquids, *capsicin* and *capsicol*, combined with capsaicin and fat. *Capsaicin* is a pungent body, having the formula $C_9H_{14}O_2$. Most analyses of red pepper have been made with the fruit of Capsicum annuum.

Remarks.—Capsicum belongs to the natural order Solanaceæ, the same family of plants to which belongs the Irish potato, the tomato, and the egg-plant; as well as the poisonous drugs, stramonium, belladonna, and hyoscyamus. The official fruit—the pepper pod—is so well known that extended comment is unnecessary.

Medical Properties.—Stimulant, rubefacient, condiment. The *tincture* (p. 225) and *oleoresin* (p. 254) are official. From the latter the *plaster* (p. 342) is prepared.

Dose.—Of drug, 60 milligrammes (1 grain).

PIPER—Pepper

(Black Pepper)

The dried, unripe fruit of *Piper nigrum* Linné (Fam. *Piperaceæ*), without the presence or admixture of more than 2 per cent. of stems or other foreign matter.

Constituents.—Volatile oil, resin, *piperine* (p. 800), *chavicin*. The volatile oil contains dipentene, phellandrene and caryophyllene.

Remarks.—Pepper is what is commonly called black pepper, red pepper being given the distinctive name capsicum. Note that pepper is the unripe fruit of *Piper nigrum*, the berry which was picked before fully ripe and shriveled through drying. White pepper represents the same fruit allowed to ripen, after which the fleshy portion is removed by hand, leaving only the seed, with a trace of fruit tissue clinging thereto.

Medical Properties.—Irritant, stimulant, condiment. Usually administered in tonic pills as *oleoresin* (p. 255).

Dose.—500 milligrammes (8 grains).

CUBEBA—Cubeb

(Cubeb—Cubebs)

The dried, full-grown, unripe fruits of *Piper Cubeba* Linné filius (Fam. *Piperaceæ*), without the presence or admixture of more than 5 per cent. of stems and other foreign matter.

Constituents.—Volatile oil 10 to 18 per cent.; resin; *cubebic acid; cubebin.* The latter is apparently a derivative of piperonal.

Remarks.—This drug is an unripe berry, just as is pepper, and from a closely allied plant, both plants belonging to the same genus.

Medical Properties.—Urinary disinfectant, stimulant.

Official Preparations.—The *oil* and *oleoresin* (p. 254) are used in gonorrhea mixtures, while the *lozenges* (p. 321) made from the oleoresin are used in bronchitis. The ground drug, smoked as cigarettes, has enjoyed considerable popularity as a remedy for catarrhal troubles.

Dose.—1 gramme (15 grains).

OLEUM CUBEBÆ—Oil of Cubeb

(Ol. Cubeb.—Cubeb Oil)

A volatile oil distilled from the unripe fruit of *Piper Cubeba* Linné filius (Fam. *Piperaceæ*). Preserve it in well-stoppered, amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, or pale green, or greenish-yellow liquid; characteristic odor and taste; sp. gr. 0.905 to 0.925; optical rotation −20° to −40° in 100-mm. tube. For details see U.S.P., p. 291.

Composition.—Two sesquiterpenes, one of which is cadinene; some terpenes (pinene and dipentene), etc. Old oil contains a sesquiterpene alcohol, $C_{15}H_{24}H_2O$, called cubeb camphor.

Medical Properties.—Used largely in gonorrhea mixtures.

Dose.—0.5 mil (8 minims).

HUMULUS—Hops

(Humul.)

The carefully dried strobiles of *Humulus Lupulus* Linné (Fam. *Moraceæ*) bearing their glandular trichomes and without the presence or admixture of more than 2 per cent. of stems, leaves and other foreign matter. Preserve it in tightly closed containers, protected from light.

Constituents.—Volatile oil; resins; *humulol* (a crystalline principle, $C_{17}H_{18}O_4$); nitrogenous matter (choline, asparagine, etc.) tannin; sugar, etc.

The resins are combinations of ceryl alcohol and phytosterols with various fatty acids. The volatile oil consists of a sesquiterpene, *humulene*, 66 per cent., some olefinic terpenes, oxygenated products, etc.

Remarks.—Hops are strobiles of *Humulus Lupulus*, the strobile being the chaffy, scale-like form in which the flowers of hops arrange themselves. They are somewhat similar to the pine-cone, and at the base of each scale the fruit is found—in the form of a minute nutlet. The inner surface of the chaffy scales of hops are found covered with hair-like appendages called by the pharmacopœia "glandular trichomes," and these trichomes, shaken from the dry hops, constitute lupulin, which is official. The medical action of these two drugs is, therefore, quite similar. Hops are chiefly used in the manufacture of beer.

Medical Properties.—Tonic and hypnotic, chiefly in domestic practice—hop-poultice, etc.—as in medicine the more active lupulin is preferred.

Dose.—2 grammes (30 grains).

Lupulinum (U.S.P. VIII; N.F. IV), or *lupulin*, are the glandular trichomes separated from the strobiles of *Humulus Lupulus* Linné (Fam. *Moraceæ*). Their constituents are identical with those of hops and in more concentrated form, and the drug is used like hops in 8-grain doses.

DRUGS CONTAINING VOLATILE OIL, RESIN, AND BITTER PRINCIPLE

Drugs of this class closely resemble those just considered, the only difference being that while in the class just considered the aromatic feature prevailed, the drugs now to be taken are bitter rather than aromatic. The bitter principles found in these drugs have not in most cases been carefully studied.

PYRETHRUM—Pyrethrum

(Pyreth.—Pellitory Root)

The dried root of *Anacyclus Pyrethrum* (Linné) De Candolle (Fam. *Compositæ*). Preserve Pyrethrum in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Acrid resin; fixed oil; much inulin; no starch; *pyrethrine* (an alkaloid).

Remarks.—Pellitory scarcely belongs in this class of drugs, as there is no mention in literature as to its containing volatile oil, nor is it strikingly bitter.

Medical Properties.—Sialagogue and irritant. It is seldom used, but is said to be efficient in toothache. The *tincture* (p. 231) is official.

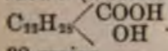
Dose.—Of drug, 2 grammes (30 grains).

Cypripedium (U.S.P. VIII; N.F. IV), or *lady slipper root*, is the rhizome and roots of several species of *Cypripedium*. It contains volatile oil, resins, volatile acid and bitter glucoside, and is used as an antispasmodic in 15-grain doses.

Salvia, or *sage*, is the dried leaves of *Salvia officinalis* Linné (Fam. *Labiatæ*). Sage contains volatile oil, tannin, etc. The *volatile oil* consists of thujone, 50 per cent.; pinene, cineol, and borneol. It is used as a carminative, astringent and flavor in 30-grain doses.

Eupatorium (U.S.P. VIII; N.F. IV), commonly called *boneset* or *thoroughwort*, is the dried leaves and flowering tops of *Eupatorium perfoliatum* Linné (Fam. *Compositæ*). It contains volatile oil, and a bitter principle *eupatorin*. It is used as a bitter stomachic in 30-grain doses.

Marrubium (U.S.P. VIII), or *horehound*, consists of the dried leaves and flowering tops of *Marrubium vulgare* Linné (Fam. *Labiatæ*). It contains volatile oil, resin, *marrubiin* (a bitter principle melting at 160°C.), which is the lactone of *marrubic acid*,



$C_{13}H_{25}\left\langle\begin{matrix}COOH\\OH\end{matrix}\right.$. It is a stimulant, tonic, popular domestic cough remedy. *Dose.*—30 grains.

Anthemis (U.S.P. VIII), or *Roman chamomile*, is the dried flower-heads of *An-*

themis nobilis Linné (Fam. *Compositæ*), collected from cultivated plants. This drug, also called *English chamomile,* contains volatile oil, anthemic acid and a glucoside. Power and Browning have isolated nine other constituents, among them apigenin, $C_{15}H_{10}O_5$, choline, phytosterols and fatty acids. The volatile oil consists of a mixture of the esters of isobutyl, amyl, and hexyl alcohols with butyric and angelic acids. It is used as a carminative, stimulant, emmenagogue, in 30-grain doses.

MATRICARIA.—Matricaria

(**Matricar.**—German Chamomile—Wild Chamomile)

The dried flower-heads of *Matricaria Chamomilla* Linné (Fam. *Compositæ*), without the presence or admixture of more than 5 per cent. of stems and foreign matter. Preserve it in tightly closed containers and guard against attack by insects.

Constituents.—Volatile oil, which is blue in color; bitter principle, fat, wax, resin gum, etc.

Medical Properties.—Like anthemis.

Dose.—15 grammes (4 drachms).

Calendula (U.S.P. VIII; N.F. IV), or *marigold*, represents the dried ligulate florets of *Calendula officinalis* Linné (Fam. *Compositæ*).

The drug contains volatile oil; resin; fixed oil but no tannin. Calendula belongs to the largest of all plant families, the Compositæ, or sunflower family. The type of the family is the sunflower, the large so-called "flower" of which is really a large collection of small flowers arranged in a close cluster or head. An examination of the sunflower will show this: the black, brush-like disc being composed of florets of one sort (the tubular), while the outer row is composed of florets with a large yellow expansion of the petal on one side. As this expansion is somewhat strap-shaped, such little flowers as have them are called ligulate, from the Latin *ligula*, a strap. Flower-heads, like the sunflower, being compounded of many little flowers, are grouped into a plant family called the Compositæ. To this family belong the two chamomiles and arnica, and an examination of any of these will show the many little florets that go to make up the flower-head, while the calendula consists of the ligulate florets only.

ARNICA—Arnica

(**Arnica.**—ArnicaFlowers)

The dried flower-heads of *Arnica montana* Linné (Fam. *Compositæ*).

Constituents.—Volatile oil; resin; *arnicin; arnicine.*

Medical Properties.—Irritant and vulnerary. Used chiefly externally in the form of the official *tincture* (p. 223).

Dose.—Of drug, 1 gramme (15 grains).

Arnica root, U.S.P. 1890, contains about the same constituents as the flowers and is used for the same purpose.

OLEORESINS AND BALSAMS

In this class we group those drugs which are plant exudations and consist of a mixture of volatile oil and resin (*natural oleoresins*) or of an oleoresin containing benzoic, cinnamic, and other aromatic acids (*balsams*). We have already studied (p. 252) pharmaceutic oleoresins, those bodies prepared by extracting the oil and resins from such plant drugs as we have just considered—*e.g.*, capsicum, cubeb, etc.—by percolation with acetone, ether, or alcohol. The oleoresins we will now consider are natural exudations, oozing from trunks of trees through natural fissures or artificial incisions.

Terebinthina (U.S.P. VIII; N.F. IV) or *turpentine* is a concrete oleoresin obtained from *Pinus palustris* Miller, and from other species of *Pinus* (Fam. *Pinaceæ*). It contains volatile oil, 22.5 per cent.; resin, 70 per cent. (rosin, U.S.P.). This substance is familiarly and incorrectly called "gum turpentine." Already it has been mentioned that the modern idea of a gum is a substance soluble in water and insoluble in alcohol. As turpentine is insoluble in water and soluble in alcohol, it is clear it should no longer be considered among the "gums."

We will consider rosin in the chapter devoted to Resinous Bodies, at which time its chemistry will be discussed. Turpentine is a stimulant used almost entirely as a plaster base.

OLEUM TEREBINTHINÆ—Oil of Turpentine

(Ol. Tereb.—Turpentine Oil "Spirits of Turpentine")

The volatile oil distilled with water, from the concrete oleoresin obtained from *Pinus palustris* Miller or from other species of *Pinus* (Fam. *Pinaceæ*). Preserve it in well-closed containers.

Summarized Description.

Colorless liquid; characteristic odor and taste, which grows stronger on aging; soluble in 5 volumes of alcohol; sp. gr. 0.860 to 0.870; on distillation, 90 per cent. of the oil passes over between 154° and 170°C. For details see U.S.P., p. 302.

For *tests for identity*, for *impurities:* Fixed oils (evaporated from filter paper without leaving a permanent stain).

Mineral oil (mixed cautiously with fuming sulphuric acid in a cassia flask and then filled with sulphuric acid to the graduations in the neck, not more than 1 per cent. of the original volume of oil remains.) See U. S. P.

Composition.—Chiefly pinene. The American oil is dextrogyrate, while the French oil is levogyrate. Otherwise the two are practically identical.

Remarks.—This represents the average *spirits of turpentine* of commerce. Note that the presence of mineral oil is detected by treatment with fuming sulphuric acid. This chemical destroys most of the oil of turpentine whereas mineral oils are unaffected by such vigorous treatment. Note also that the refractive index figures in the pharmacopœial test.

Medical Properties.—Stimulant, antiseptic, urinary disinfectant. The pharmacopœia directs that for internal use the *rectified oil* should be employed.

OLEUM TEREBINTHINÆ RECTIFICATUM—Rectified Oil of Turpentine

(Ol. Tereb. Rect.—Rectified Turpentine Oil)

Condensed Recipe.

Shake oil of turpentine with solution of sodium hydroxide and then distil. Collect about three-fourths of the original oil as distillate, separate it from the aqueous distillate, dry it with calcium chloride and then filter. For details see U.S.P., p. 303.

Summarized Description.

Colorless liquid; sp. gr. 0.856 to 0.865; leaves less than 0.2 per cent. residue on evaporation; for other tests, see oil of turpentine.

Remarks.—It will be seen that this represents the commercial oil mixed with alkali and redistilled, and it is thus freed from resinous materials which are present in the crude oil, giving it a disagreeable odor and taste.

Medical Properties.—That of the crude oil.

Dose.—0.3 mil (5 minims).

OLEUM PINI PUMILIONIS—Oil of Dwarf Pinee Nedles

(Ol. Pin. Pumil.—Dwarf Pine Oil)

A volatile oil distilled from the fresh leaves of *Pinus montana* Miller (*Pinus Pumilio* Haenke) (Fam. *Pinaceæ*). Preserve it in well-stoppered amber-colored bottles, in a cool place, protected from light.

Summarized Description.

Colorless, or faintly yellowish oil; pleasantly aromatic odor; bitter, pungent taste; sp. gr. 0.853 to 0.869; none of it distils below 170°C. For details see U.S.P., p. 299.

Remarks.—This new official oil represents the distillate from the fresh leaves of the dwarf pine.

Oleum templinum on the other hand, is the distillate from the twigs and the cones of Pinus pumilio; while *pine wood oil* is the distillate from the "light wood" of Pinus palustris. Each of these oils are obtained from its respective source by distillation with steam. The first two are used in inhalers and vaporizers in catarrhal troubles; while pine wood oil is now largely used as a solvent.

Terebinthina Canadensis (U.S.P. VIII) or *balsam of fir* is a liquid oleoresin obtained from *Abies balsamea* (Linné) Miller (Fam. *Coniferæ*). It contains volatile oil, acid resins, and indifferent resins. The *volatile oil* is chiefly lævogyrate pinene. The balsam is used as a stimulant and for mounting microscopic specimens, the object being embedded in a hard, transparent varnish after standing.

Terebinthina Laricis N.F. or *Venice turpentine* is the oleoresin from *Larix europoea*, the larch, a tree closely related to the pine. The product sold in American drugstores for "drawing out" splinters saw neither Venice nor the larch tree, but is made by dissolving rosin in oil of turpentine.

PIX LIQUIDA—Tar

(Pix Liq.—Pine Tar)

A product obtained by the destructive distillation of the wood of *Pinus palustris* Miller, or of other species of *Pinus* (Fam. *Pinaceæ*).

Summarized Description.

Semi-liquid, viscid, brownish-black non-crystalline product; empyreumatic terebinthinate odor; sharp empyreumatic taste; miscible with alcohol, ether, chloroform, glacial acetic acid, fixed and volatile oils; slightly soluble in water, the solution being yellowish to yellow-brown in color.

Constituents—Volatile oil, U. S. P.; pitch; pyroligneous acid (p. 601).

Remarks.—Tar is made by stacking billets of pine wood on the earth into a conical mound, and setting fire to the wood after covering with plastered earth. Enough air is admitted through holes in the earth covering to permit the wood to smoulder, and a hole at the top of the mound serves as a chimney. Before stacking the wood, radiating ditches are dug on the ground on which the mound is to be built, the ditches running into a circular trench surrounding the mound. The smouldering heat decomposes the wood into smoke, which passes off through the hole in the top of the mound; tar, which runs into the circular trench and is dipped into barrels; and charcoal, which is sacked after the fire is extinguished and the earth covering removed. The process has already been touched upon on pp. 83 and 601.

Medical Properties.—Stimulant and antiseptic. Used for bronchial affections as the official *syrup* (p. 198), and externally as the official *ointment* (p. 334).

Dose.—500 milligrammes (8 grains).

Glycerole of tar (N.F.) is made by mixing washed tar with alcohol, triturating mixture with magnesium carbonate and water, and filtering. It contains the equivalent of 63 Gm. tar to the liter. A simpler recipe consists in mixing 1 fluidounce oil of tar with 2 fluidounces of alcohol, triturating to smooth paste with 6 drachms magnesium carbonate, adding 4 fluidounces glycerin and 4 fluidounces water, macerating several days, and then filtering. (See p. 212).

Liquor picis alkalinis (N.F.) is a solution of pine tar in potassium hydroxide. (See p. 191.)

Coal tar is a side product in the manufacture of illuminating gas (p. 686). It is described in the National Formulary under the title, *pix lithanthracis*.

Liquor picis carbonis (N.F.) is a solution of coal tar in alcohol, quillaja being used to facilitate solution.

OLEUM PICIS LIQUIDÆ RECTIFICATUM—Rectified Oil of Tar

(Ol. Pic. Liq. Rect.—Rectified Tar Oil)

A volatile oil distilled from Tar.

Summarized Description.

Thick, dark-reddish-brown liquid; strong empyreumatic odor and taste; soluble in alcohol, sp. gr. 0.960 to 0.990. For details see U.S.P., p. 298.

Composition—A vast number of products similar to those obtained in the manufacture of crude pyroligneous acid, such as toluene, xylene, mesitylene, phenol, creosote, naphthalene, etc.

Medical Properties.—Stimulant and antiseptic.

Dose.—0.2 mil (3 minims).

OLEUM CADINUM—Oil of Cade

(Ol. Cadin.—Cade Oil—Oil of Juniper Tar—Oleum Juniperi Empyreumaticum)

An empyreumatic oil obtained by the dry distillation of the wood of *Juniperus Oxycedrus* Linné (Fam. *Pinaceæ*).

Summarized description.

Dark-brown, clear thick liquid; tarry empyreumatic odor; faintly aromatic, bitter taste; almost insoluble in water; partly soluble in alcohol and in petroleum benzin; completely soluble in ether, amyl alcohol, chloroform, glacial acetic acid and oil of turpentine; sp. gr. 0.980 to 1.055. For details see U.S.P., p. 288.

For *tests for identity*, for *impurities:* Rosin and rosin oil (solution in petroleum benzin not turned green on addition of copper acetate solution), see U.S.P.

Composition.—Phenols, resin, large amount of cadinene.

Medical Properties.—Like tar, chiefly externally.

COPAIBA—Copaiba

(Copaib.—Balsam of Copaiba—Copaiva)

An oleoresin derived from South American species of *Copaiba* (Fam. *Leguminosæ*).

Summarized Description.

Pale yellow or brownish-yellow viscid liquid; sometimes slightly fluorescent; peculiar aromatic odor; bitter, acrid taste; insoluble in water; partly soluble in alcohol; soluble with some opalescence in dehydrated alcohol and carbon disulphide; entirely soluble in chloroform and ether; sp. gr. 0.940 to 0.995; acid value, 28 to 95. For details see U.S.P., p. 123.

For *tests for identity* and for *impurities:* Paraffin and fatty oils (resin left after distillation, is hard and brittle; yield not less than 36 per cent.). Gurjun balsam (steam distilled volatile oil treated with acetic acid and sodium nitrite solution and then layered on sulphuric acid, should not give a pink upper layer). Paraffin oils (hot alcoholic solution on standing deposits no oil). African copaiba (volatile oil distils above 250°C. and is levorotatory). See U.S.P., p. 123.

Constituents.—Volatile oil (80 per cent. in best quality), resin (p. 774.)

Remarks.—Copaiba has been largely adulterated, hence lengthy tests given above. For making mass of copaiba, U.S.P. 1890, samples containing large amounts of resin should be employed, such as the Maracaibo copaiba, which contains only 30 per cent. to 40 per cent. oil.

Medical Properties.—Urinary antiseptic. Popular remedy for gonorrhea, administered in emulsion. The National Formulary gives recipes for two such emulsions, *Lafayette mixture* and *Chapman's mixture.* (See p. 258.)

Dose.—1 mil (15 minims).

Oleum Copaibæ (U.S.P. VIII) is a volatile oil distilled from copaiba. It contains sesquiterpenes (α and β caryophyllenes, cadinene, etc.) and is used like copaiba, in 8-minim doses.

OFFICAL BALSAMS

Balsams are natural products, differing from oleoresins only in containing benzoic and cinnamic acids, the presence of which give the balsams their delightful odor. As all so-called "gums" are not true gums, even so every substance termed a balsam does not come within the pharmaceutic meaning of that term. For instance, copaiba is not a true balsam, since it contains neither benzoic nor cinnamic acid. It is an oleoresin pure and simple.

BALSAMUM PERUVIANUM—Balsam of Peru

(**Bals. Peruv.**—Peru Balsam)

A balsam obtained from *Toluifera Pereiræ* (Royle) Baillon (Fam. *Leguminosæ*).

Summarized Description.

Viscid dark-brown liquid, free from stringiness or stickiness; transparent reddish-brown in thin layers; agreeable vanilla-like odor; bitter acrid taste; does not harden on exposure to the air; soluble in alcohol, chloroform and glacial acetic acid (sometimes with slight opalescence); partly soluble in ether or petroleum benzin; practically insoluble in water; sp. gr. 1.130 to 1.160; acid number, 56 to 84. For details see U.S.P. p. 70.

For *tests for identity* and for *impurities:* Fixed oils (gives clear fluid with hydrated chloral solution).

Turpentine or rosin (residue from hot petroleum benzin solution not turned green or blue by nitric acid). See U. S. P.

Saponification Number.—235 to 238. Details in Part V.

Constituents.—Volatile oil (called *cinnamein*), 60 per cent.; resin, 30 per cent., benzoic and cinnamic acids; vanillin, etc.

The *volatile oil* consists of benzyl alcohol, benzylic benzoate, and benzylic cinnamate.

The *resin* yields 66 per cent. protocatechuic acid, on fusing with potassium hydroxide, and is an ester of peru-resinol with cinnamic and benzoic acids.

Remarks.—Of the tests given above, reference need be made only to the cinnamein assay, which concluded with estimation of its saponification number, performed like the assay of oil of peppermint (p. 747). "Synthetic" balsam of peru is now found in the German market.

Medical Properties.—Stimulant, antiseptic. Chiefly externally.

Dose.—1 gramme (15 grains).

BALSAMUM TOLUTANUM—Balsam of Tolu

(Bals. Tolu.—Tolu Balsam.)

A balsam obtained from *Toluifera Balsamum* Linné (Fam. *Leguminosæ*).

Summarized Description.

Yellowish-brown or brown plastic solid; brittle when old or dry or cold; transparent in thin layers; pleasant aromatic vanilla-like odor; mild aromatic taste, nearly insoluble in water and in petroleum benzin; soluble in alcohol, chloroform and ether; mostly soluble in solutions of fixed alkalies. For details see U.S.P., p. 71.

For *tests for identity*, for *impurities:* Rosin or copaiba (carbon disulphide extract redissolved in glacial acetic acid, is not made green either by sulphuric acid nor by copper acetate solution). See U.S.P.

Saponification Number.—154 to 220. Details in Part V.

Constituents—Volatile oil; two resins; benzoic and cinnamic acids; esters of these two acids with benzyl alcohol. The composition of volatile oil not known.

Medical Properties.—Flavor, stimulant, popularly used as an expectorant in the form of the official *syrup* (p. 200), which is made from the official *tincture* (p. 233). A constituent of *compound tincture of benzoin* (p. 224).

Dose.—1 gramme (15 grains).

STYRAX—Storax

(Liquid Storax)

A balsam obtained from the wood and inner bark of *Liquidambar orientalis* Miller (Fam. *Hamamelidaceæ*).

Summarized Description.

Semi-liquid grayish sticky opaque mass, depositing on standing a dark-brown stratum; transparent in thin layers; characteristic odor; acrid taste; insoluble in water; soluble in 1 volume of warm alcohol; mostly soluble in ether, acetone, benzene and carbon disulphide. For details see U.S.P., p. 417.

For *tests for identity*, see U.S.P.

Acid Number.—56 to 85. Details in Part V.

Saponification Number.—170 to 230. Details in Part V.

Constituents.—Volatile oil; resin; benzoic and cinnamic acids; *styracine* (cinnamate of cinnamyl) and other esters; vanillin; *cinnamene* (or *styrol*), $C_6H_5CH=CH_2$.

The *volatile oil* consists of cinnamene, styrocamphene, and esters of cinnamic acid.

Remarks.—This product, while quite similar to the "*sweet gum*" of the southern States, is not identical therewith, the latter being the exudation of *Liquidambar styraciflua*.

Medical Properties.—Similar to balsam of Peru. A constituent of *compound tincture of benzoin* (p. 227).

Dose.—1 gramme (15 grains).

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Pimenta.—(Constituents) Bonastre, Jl. de Ph., 11, 1825, 187 and 13, 1827, 466.

Oil of Pimenta.—(Constituents) Oeser, A., 131, 1864, 277.

Cardamom.—(Constituents) Stern, Zt. angew. ch., 6, 1893, 137; Weber, A., 238, 1887, 98; Anon., Schimmel's Rep., Oct., 1897, 11. (Properties) Parry, Ph. Jl., 63, 1889, 105.

Sabal.—(Constituents) Schreiner, Ph. Rev., 18, 1900, 217; Sherman and Briggs, Pharm. Arch., 2, 1899, 101; Mann, Pharm. Era, 49, 1916, 89.

Bitter Orange Peel.—(Constituents) Tanret, Ph. Jl., 16, 1886, 839; Tiemann, B., 14, 1881, 970.

Sweet Orange Peel.—(Constituents) Lebreton, Jl. de Ph., 14, 1828, 377; Helger, B., 9, 1876, 26; Hoffmann, B., 9, 1876, 685.

Oil of Orange Peel.—(Constituents) Wallach, A., 227, 1885, 289; Semmler, B., 24, 1891, 202; Parry, Ch. and Dr., 56, 1900, 462; Dowzard, A.J.P., 80, 1908, 474. (Preservation) LaWall, A.Ph.A., 58, 1910, 1121.

Lemon Peel.—(Constituents) Cogswell, A.J.P., 26, 1854, 553; Hoffmann (see above).

Oil of Lemon.—(Manufacture) Flückiger, Arch. d. Pharm., 227, 1889, 1065. (Constituents) Wallach, A., 227, 1885, 290; Semmler, B., 24, 1891, 203: Doebner, B., 27, 1894, 352; Anon., Schimmel's Rep., Oct., 1897, 26; Umney and Swinton, Ph. Jl., 61, 1898, 196 and 370; Anon., Schimmel's Rep., Oct., 1909, 62.

Myristica.—(Constituents) Bonastre, Jl. de Ph., 9, 1823, 281; Stern, Zt. angew. Ch., 6, 1893, 137; Power and Salway, Jl. Ch. Soc., 91, 1907, 2037, 93, 1908, 1653.

Oil of Myristica.—(Constituents) Power and Salway (see above); Wallach, A. 252, 1889, 105.

Myristicin.—(Structure) Semmler, B., 24, 1891, 3818. (Pharmacology) Power and Salway, A.J.P., 80, 1908, 563.

Stillingia.—(Constituents) Saunders, A.Ph.A., 16, 1868, 460; Harmanson, A.J.P., 54, 1882, 386; Bichy, A.J.P., 57, 1885, 529.

Sumbul.—Reinsch and Buchner, A.J.P., 16, 1844, 119; Reinsch and Riekher, A., 68, 1848, 341; Heyl and Hart, Jl. Am. Ch. Soc., 38, 1916, 432.

Aspidium.—(Constituents) Bock, A.J.P., 24, 1852, 61; Luck, Ch. Cent., 22, 1851, 657 and 676; Grabowsky, Ch. Cent., 38, 1867, 469; Daccoma, A.J.P., 61, 1889, 144; Ehrenberg, Arch. d. Pharm., 231, 1893, 345.

Ginger.—(Constituents) Thresh, A.Ph.A., 28, 1880, 83, 31, 1883, 257 and 33, 1885, 257, Ph. Jl., [3], 12, 1881, 243; Gane, Ph. Jl., [3], 22, 1892, 802; Bertram and Walbaum, Jl. prakt. Ch., 49, 1894, 18; Stenhouse and Groves, A.Ph.A., 26, 1878, 193; Brooks, Jl. Am. Ch. Soc., 38, 1916, 430.

Calamus.—(Constituents) Griffith, A.J.P., 5, 1833, 265; Faust, Arch. d. Pharm., 181, 1867, 214; Thoms, Arch. d. Pharm., 224, 1886, 465; Kurbatow, A., 173, 1874, 4; Thoms and Beckstrom, B., 34, 1901, 1021 and 35, 1902, 3187.

Cimicifuga.—(Constituents) Finnemore, A.Ph.A., 58, 1910, 195.

Serpentaria.—(Constituents) Serullas, Jl. de Ph., 6, 1820, 571; Peacock, A.J.P., 63, 1891, 257; Ferguson, A.J.P., 59, 1887, 481.

Xanthoxylum.—(Constituents) Staples, A.J.P., 1, 1829, 163; Griffith, A.J.P., 8, 1836, 195; Eberhardt, A.J.P., 72, 1890, 231; Gordin, Jl. Am. Ch. Soc., 28, 1906, 1649.

Mezereum.—(Description) Squire, Ph. Jl., 1, 1842, 395. (Constituents) Gmelin and Bär, through Berzelius' Traité de Chimie, 3, 1839, 116; Zwenger, A., 115, 1860, 1.

Matico.—(Description) Dierbach, A., 20, 1836, 266. (Constituents) Hodges, A.J.P., 18, 1847, 178; Niegans, A.J.P., 18, 1847, 174; Thoms, Arch. d. Pharm., 247, 1909, 591.

Yerba Santa.—(Constituents) Mohr, A.Ph.A., 27, 1879, 736; Power and Tutin, Proc., A.Ph.A., 54, 1906, 352 and Proc. Ch. Soc. Lond., 23, 1907, 133. (Uses) Hartz, Am. Dr., 15, 1886, 41; Stevens, A.Ph.A., 36, 1888, 89.

Grindelia.—(Constituents) Power and Tutin, A.Ph.A., 53, 1905, 193.

Savin.—(Constituents) Needles, A.J.P., 13, 1841, 11.

Oil of Savin.—(Composition) Fromme, B., 31, 1898, 2025; Wallach, A., 238, 1887, 82.

Cannabis Indica.—(Description) Anon., Ph. Jl., 1, 1842, 489. (Constituents) Schlesiger Buchner's Repert, 21, 1840, 190; Smith, Ph. Jl., 6, 1846, 171; Personnes, Jl. de ph. et. ch., 31, 1857, 48; Robiquet, Jl. de ph. et. ch., 31, 1857, 46; Humphrey, Ph. Jl., 68, 1902, 342; Marshall, A.Ph.A., 51, 1903, 804; Smith, A.J.P., 63, 1891, 38; Bombelon, Am. Dr., 13, 1884, 132; Valente, B., 13, 1880, 2431 and 14, 1881, 1717. (American Cannabis) Houghton and Hamilton, A.Ph.A., 55, 1907, 445. (Deterioration) Marshall, Dr. Circ., 53, 1909, 578. (Hashisch) Ball, Therap. Gaz., 34, 1910, 777.

Capsicum.—(Constituents) Taylor, A.J.P., 29, 1857, 303; Thresh, Ph. Jl., [3], 7, 1876, 21 and 259; Pabst, Arch. d. Pharm., 230, 1892, 108; Buchheim, A.Ph.A., 22, 1874, 106.

Pepper.—(History) "X-rayser," Ch. and Dr., 84, 1914, 403. (Constituents) Poutel, Jl. de Ph. ,7, 1821, 373; Buchheim, A.J.P., 48, 1876, 467; Eberhardt, Arch. d. Pharm., 225, 1887, 515; Anon., Schimmel's Rep., Oct., 1890, 49; Kremers and Schreiner, Ph. Arch., 4, 1901, 61. (White pepper) Parry, 79, 1911, 167.

Cubeb.—(Constituents) Vauquelin, Jl. de Ph., 6, 1820, 309; Monheims, A.J.P., 18, 1846, 168; Schmidt, A.J.P., 42, 1870, 222; Schulze, Arch. d. Pharm., 202, 1873, 388; Mameli, C. A., 7, 1913, 1722.

Oil of Cubeb.—(Composition) Wallach, A., 238, 1887, 78; Oglialore, B., 8, 1875, 1357. (Cubeb camphor) Schmidt, B., 10, 1877, 188; Schaer and Wyss, Arch. d. Pharm., 206, 1875, 316.

Eupatorium.—(Constituents) Peterson, A.J.P., 23, 1851, 206; Bickley, A.J.P., 26, 1854; 495; Latin, A.J.P., 52, 1880, 392.

Marrubium.—(Constituents) McMaken, A.J.P., 17, 1845, 1; Gordin, Jl. Am. Ch. Soc., 30, 1908, 265.

Anthemis.—(Constituents) Amerman, A.J.P., 61, 1889, 69; Power and Browning, Ch. and Dr., 85, 1914, 376; Fittig and Kopp, B., 9, 1876, 195 and 10, 1877, 53; Fettig and Köbig, A., 195, 1879, 79.

Matricaria.—(Constituents) Gerhardt, Ph. Jl., [2], 3, 1862, 429; Herberger and Damur, A., 8, 1833, 231; Hartwich and Jama, A.Ph.A., 58, 1910, 302; Henderson, Ph. Jl., 81, 1908, 683.

Calendula.—(Constituents) Geiger, through Berzelius' Traité de Chimie, 3, 1839, 153; Teelke, A.J.P., 63, 1891, 477.

Hops.—(Constituents) Power, Tutin and Rogerson, Jl. Ch. Soc., 103, 1913, 1267; Chapman, Jl. Ch. Soc., 67, 1895, 54 and 780, 83, 1903, 505 and Ch. and Dr., 84, 1914, 980; Semmler and Mayer, B., 44, 1911; 2009.

Pyrethrum.—(Constituents) Koehn, A.J.P., 1836, 175; Schneegans, A.Ph.A., 45, 1897, 736.

Cyprepedium.—(Constituents) Blair, A.J.P., 38, 1866, 494; Beshore, A.J.P., 59, 1887, 395.

Sage.—(Constituents) Ilish, through Berzelius' Traité de Chimie, 3, 1839, 147; Muir, Ph. Jl., [3], 7, 1876, 265; Wallach, A., 227, 1885, 289, 252, 1889, 103 and 286, 1895, 93; Anon., Schimmel's Rep., Oct., 1895, 42.

Arnica.—(Constituents) Walz, A.J.P., 33, 1861, 450; Börner, A.Ph.A., 41, 1893, 637.

Turpentine.—(Gathering) Herty, U. S. Dept. Agr. Forest Service, Bull. No. 90. (Constituents) Kremers, Ph. Rund., 13, 1895, 135. (Foreign turpentines) Tschirch and students, A.Ph.A., 49, 1901, 744.

Oil of Turpentine.—(Composition) Kremers, Ph. Rund., 13, 1895, 135; De Voy, Ch. Cent., 74, 1867, 304. (Purification) Szigethy, A.Ph.A., 45, 1897, 638.

Pine Needle Oil and *Oleum Templinum.*—Morel, Ph. Jl., [3], 8, 1877, 726; Anon., Schimmel's Rep., April, 1909, 79, and April, 1910, 91; Ludy, A.Ph.A., 56, 1908, 336.

Pine Wood Oil.—Teeple, Jl. Am. Ch. Soc., 30, 1908, 412.

Canada Turpentine.—(Constituents) Morel, Ph. Jl., [3], 8, 1877, 22; Emmerich, A.J.P., 67, 1895, 135; Tschirch and Brüning, Arch. d. Pharm., 238, 1900, 487.

Venice Turpentine.—(Constituents) Morel, Ph. Jl., [3], 8, 1877, 21; Andes, C. A., 6, 1912, 2853.

Tar.—(Preparation and properties) Dunwody, A.J.P., 61, 1889, 600. (Constituents, P. sylvestris) Stroem, Arch. d. Pharm., 237, 1899, 525.

Birch Tar.—(Constituents) Hlasiwetz, A., 106, 1858, 339; Gorup-Besanez, A., 143, 1867, 129; Tiemann and Koppe, B., 14, 1881, 2005.

Glycerite of Tar.—Wiegand, A.J.P., 56, 1881, 8.

Liquor Picis Carbonis.—Raubenheimer, A.Ph.A., 57, 1909, 131.

Oil of Tar.—(Composition) Stroem (see above).

Oil of Cade.—(Preparation) Planchon, Schw. Wsch. Ch. u Ph., 50, 1912, 166. (Composition) Troeger and Feldmann, Arch. d. Pharm., 236, 1898, 692; Wallach, A., 238, 1881, 82 and 271, 1892, 297.

Copaiba.—(Constituents) Procter, A.J.P., 22, 1850, 289; Maisch, A.J.P., 35, 1863, 17; Strauss, A., 148, 1868, 148. (Tests) Deussen, Arch. d. Pharm., 252, 1914, 590.

Oil of Copaiba.—(Composition) Deussen and Hahn, Ch. Zt., 34, 1910, 872; Anon., Schimmel's Rep., Oct., 1910, 185.

Balsam of Peru.—(Constituents) Trog, Arch. d. Pharm., 232, 1894, 70; Thoms, A.Ph.A., 48, 1900, 649; Kraut, A., 153, 1870, 129; Kaehler, B., 2, 1869, 512. (Synthetic" balsam) Anon., A.Ph.A., 56, 1908, 238.

Balsam of Tolu.—(Constituents) Kopp, Jl. de ph. et ch., 11, 1847, 425; Schorling, A., 97, 1856, 71; Busse, B., 9, 1876, 833.

Storax.—(Constituents) Bonastre, A.J.P., 4, 1832, 210; Schorling, A., 97, 1856, 90; Miller, A., 188, 1877, 184; Laubenheimer, A., 164, 1872, 289; Van't Hoff, B., 9, 1876, 5.

CHAPTER XLVIII

RESINS AND NEUTRAL PRINCIPLES

THIS chapter deals with plant principles, of which less is known than any other group of chemical substances—in truth, the only reason why these bodies are grouped into this chapter is because they have not been sufficiently studied to know to what classes of chemicals they belong, and as its composition is worked out, each body will be placed in its appropriate position in systematic chemistry, leaving nothing for discussion in this chapter.

This work is already begun. It is now known that resin of jalap owes its activity to the glucoside, convolvulin; while resin of scammony is active because of its glucoside, scammonin; therefore, these two so-called resins are considered among the glucosidal drugs.

The phrase "resin acid" is here used in the attempt to classify the important constituent found in the several plant products which we call *resins*. These bodies are best defined as plant substances soluble in alcohol, insoluble in water, and dissolving in alkalis to form "resin soaps." Hence they are acid in character. Whether all the resins considered in this chapter will on investigation comply with this definition remains to be seen, and let it be distinctly understood that practically all resins are far more complex than the above definition implies.

Tschirch has attempted a classification of resins as follows:

Resin Esters or Their Saponification Products: (*Resines.*)

These esters are combinations of aromatic acids, such as benzoic, cinnamic, and ferulic acids, with resin alcohols (resinoles).

The resin alcohols can be grouped into two classes, according as they do or do not give the tannin reaction, the latter class being called resin-tannols. Among the tannin-free resinols may be mentioned *storesin* in storax; while as examples of resin tannols may be cited *toluresin tannol* in balsam of tolu.

Resinol Acids:

Resin acids, such as abietinic acid in rosin, guaiaconic acid in guaiac, and copaivic acid in copaiba.

Resenes:

Indifferent substances of unknown composition, such as *dracoresene* in dragon's blood.

Aliphato-resins (esters of aliphatic acids), *chromo-resins* (containing coloring matter); *enzymo-resins* (containing enzymes such as laccase); *glucoresins* (esters of resin acids with sugars, such as the glucosides found in Jalap) are known; while the so-called "milk juices" (india rubber, etc.) are now considered as *lacto-resins*.

Resins are sometimes extracted from drugs by means of solvents (example: the resin from phytolacca); sometimes represent practically entire plant exudation (example: mastic); frequently exude from plants combined with volatile oils, then forming the class of drugs called *oleoresins* (example: turpentine, U.S.P.); and often exuding mixed with gummy substances, such as exudation being called a *gum-resin* (example: asafetida). Occasionally, the resin which exudes is aromatic by reason of the benzoic and cinnamic acid it contains, the example of such a *balsamic resin* being benzoin (p. 776), while natural oleoresin similarly flavored with benzoic and cinnamic acid is called a *balsam* (example: balsam of tolu (p. 769). The last two classes of drugs as well as the oleoresins were discussed in the preceding chapter. It is advisable right here again to call attention to the distinction between natural and pharmaceutic oleoresins, already discussed on p. 253.

Neutral principles are plant principles of whose structural chemistry —of whose position in systematic chemistry—we know little or nothing. They are usually bitter and crystalline, are neither basic like alkaloids nor derivatives of glucose, as are the glucosides. That the grouping is purely artificial and temporary is shown by the fact that the most carefully studied neutral principle, santonin, is now known to be a lactone derived from hexahydrodimethyl-naphthalin and will soon be considered in text-books among the naphthalin derivatives, even as coumarin, a lactone of oxycinnamic acid, is studied among the derivatives of allylbenzene (p. 721).

RESINS, GUM-RESINS, AND DRUGS CONTAINING NEUTRAL PRINCIPLES

GUAIACUM—Guaiac

(**Guaiac.**—Guaiac Resin)

The resin of the wood of *Guaiacum officinale* Linné, or of *Guaiacum sanctum* Linné (Fam. *Zygophyllaceæ*).

Summarized Description.

Irregular, homogeneous masses; brown to greenish-gray-brown; balsamic odor, acrid taste; melts between 85° and 90°; readily soluble in alcohol, ether, chloroform, creosote, in solutions of alkalies and of hydrated chloral. For details see U.S.P., p. 211.

For *tests for identity*, for *impurities:* Rosin (petroleum benzene solution not turned green by cupric solution) see U.S.P.

Constituents.—Guaiaconic acid, (now said to be a mixture), *guaiaretic acid,* $C_{20}H_{21}O_4$, *guaiacinic acid*(or beta-resin) vanillin, volatile oil, etc.

Tschirch inclines to the belief that these so-called "acids" are resin alcohols.

Remarks.—The alcoholic solution is characterized by turning blue in the presence of oxidizing agents, such as ferric chloride (U.S.P. test).

By reason of this property filter-paper steeped in tincture of guaiac is used as a test-paper for ozone and for blood, the hematin of the latter as the oxidizing agent.

Medical Properties.—Alterative in syphilis and rheumatism. The *tincture* (p. 227) and the *ammoniated tincture* (p. 227) are official.

Dose.—Of drug, 1 gramme (15 grains).

Guaiacum Lignum (U.S.P. 1890; N.F. IV) or *guaiac wood*, the wood from which the above resin is derived. It owes its properties almost entirely to the resin, although it is said to also contain a saponin.

Mastiche (U.S.P. VIII; N.F. IV) or *mastic* is a concrete resinous exudation from *Pisticia Lentiscus* Linné (Fam. *Anacardiaceæ*).

Mastic contains *masticic acids* (two isomeres, $C_{23}H_{36}O_4$); *masticonic acids* (two isomeres, $C_{32}H_{48}O_4$); *masticolic acid*, $C_{23}H_{36}O_4$; *mastico-resenes* (the "beta" variety formerly called *masticin*); volatile oil 2 per cent. It is used as a carminative (dose, 30 grains) and is a constituent of *pills of aloes and mastic*, N.F.

Burgundy pitch is no longer official, having been dropped in the last revision. It is a resin prepared from a species of fir, and is used in medicine exclusively for the preparation of plasters.

Resin of copaiba (U.S.P. 1890), while considered as a pharmaceutic on p. 283, is worthy of a few lines devoted to its chemistry. It is the residue left on distillation of official copaiba, and consists largely of a solid acid—in this case, *copaivic acid.* As mentioned on p. 305, this acid combines with moist magnesium oxide to form a salt, and to this action is due the solidification of oleoresin in making mass of copaiba.

RESINA—Rosin

(Resin.—Colophony)

The residue left after distilling the volatile oil from the concrete oleoresin obtained from *Pinus palustris* Miller and from other species of *Pinus* (Fam. *Pinaceæ*).

Summarized Description.

Sharp, angular, translucent, amber-colored fragments; brittle at ordinary temperatures; terebinthinate odor and taste; freely soluble in alcohol, ether, benzene, glacial acetic acid, fixed and volatile oils and in diluted alkaline hydroxide solutions; sp. gr. 1.07 to 1.09. For details see U.S.P. p. 357.

Acid Number.—Not less than 150. Details in Part V.

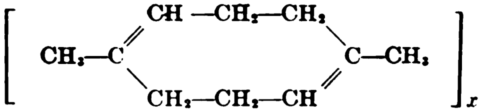
Constituents.—Chiefly *abietic acid anhydride.* Abietic acid, $C_{19}H_{28}O_2$, is obtained by digesting rosin with 70 per cent. alcohol, freeing the solution of impurities by filtration, and then dissolving the residue in hot methyl alcohol from which the abietic acid crystals separate on cooling.

Tschirch and Koritschoner, on the other hand, claim that the resin acids are *palabietinic acid*, $C_{20}H_{30}O_2$, *palabieninic acid*, $C_{13}H_{20}O_2$ and α- and β-palabietinolic acids, $C_{16}H_{24}O_2$.

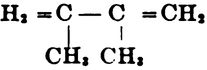
Remarks.—As already mentioned (p. 765), rosin is the resinous constituent of the natural oleoresin, *turpentine*, and is obtained by distilling the volatile oil—the so-called "spirit of turpentine"—therefrom.

Medical Properties.—Mild irritant. Use chiefly externally as constituent or plasters, cerates, and ointments. Official preparation: *Rosin cerate* (p. 329).

Elastica (U.S.P. VIII) or *rubber* is the prepared milk-juice of several species of Hevea. It is a polymerized isoprene having the formula



Constituents.—Since rubber consists largely of isoprene, the condensation (polymerization) of this hydrocarbon should produce rubber. This condensation has now been accomplished, though who was the first to obtain genuine rubber by this method is a matter of controversy. The synthesis has not as yet become financially feasible, although work to prepare cheap isoprene from dimethyl-butadiene



$$CH_2=\underset{CH_3}{C}-\underset{CH_3}{C}=CH_2$$

gives promise of ultimate success in the commercial manufacture of rubber.

The "preparation" of the milk juice mentioned in the official definition consists of submitting the fresh juice to the action of smoke made by burning fatty fuel—like palm fruit—which is allowed to smoulder with but slight access of air. The milk juice is held over the smoke on a wooden paddle, which has been dipped into a bucket containing the juice, and by deft manipulation the liquid juice is prevented from dripping from the paddle until it solidifies. The paddle containing the dried rubber is again dipped into the fresh juice, and the paddle once more rotated over the smoke until that layer has solidified, and this process continued until the paddle holds a large mass of rubber.

When heated to above 125°C., it becomes a sticky mass, and the products made from it should, therefore, be kept from undue heat. Rubber goods can best be preserved by keeping immersed in water.

Rubber is made more durable by the process of vulcanization. In making soft rubber it is kneaded with 10 per cent. sulphur (or a metallic sulphide) at a temperature of 120° to 136°C., while in making hard rubber the crude rubber is heated with 30 to 35 per cent. sulphur to 140° to 142°C., and further hardened with rosin, chalk, etc.

Rubber used in medicine is the pure native unvulcanized variety. The only medical use of rubber is as a plaster base.

Gutta Percha (N.F.) is the prepared milk-juice of various trees of the genus, Palaquium. It resembles rubber in many respects, although it is less elastic and does not readily vulcanize. It is used in surgery for preparing splints. A recipe for solution of gutta percha is given in the National Formulary (p. 190).

BENZOINUM—Benzoin

(Benzoin.—Gum Benjamin)

A balsamic resin obtained from *Styrax Benzoin* Dryander and some other species of *Styrax* (Fam. *Styracaceæ*) growing in the East Indies and known in commerce as Sumatra Benzoin and Siam Benzoin.

Constituents.—Resin, benzoic acid, cinnamic acid, vanillin, etc.

The resin of Sumatra benzoin consists chiefly of *benzoresinol*, $C_{16}H_{26}O_2$ and *benzoresinotannol*, $C_{18}H_{20}O_4$. That of the Siam variety contains benzoresinol and *siaresinotannol*, $C_{12}H_{14}O_3$.

Remarks.—Benzoin would be considered a balsam, save that the quantity of volatile oil it contains is so small that its base can hardly be considered as an oleoresin. Accordingly, the pharmacopœia calls it "a balsamic resin."

Benzoin is interesting as the original source of benzoic acid, which thus received its name.

The pharmacopœia permits the use of two commercial varieties of benzoin—Siam and Sumatra. Of these, the former possesses a delightful odor of vanilla, and is used by perfumers in preference to the less aromatic Sumatra variety. Medicinally, the two are about equal.

Medical Properties.—Expectorant. Used chiefly externally as an antiseptic and vulnerary. The *tincture* (p. 224) and the *compound tincture* (p. 224) are official. It is also used in making *benzoinated lard* (p. 661).

Dose.—1 gramme (15 grains).

Chicle is the milk-juice of *Achras Sapota*, a tree growing in Central America. It consists of the alcohols α- and β-amyrin and lupeol, combined as esters with acetic, capronic, cinnamic and benzoic acids. Its use in chewing gum is well known.

GUM—RESINS

Gum-resins are plant exudations consisting of gum and resin. We have already learned what a gum (p. 633) is, and wherein a resin (p. 773) differs from a gum, the pharmaceutic difference being one of solubility, resins dissolving in alcohols and being insoluble in water, while gums dissolve in water and not in alcohol. Again, resins are terpene derivatives, while gums are dissociation products of cellulose.

The gum of a gum-resin will not dissolve in alcohol; the resin will; and since the resin is the active constituent, tinctures of such drugs are made by maceration in 95 per cent. alcohol and filtration of the resinous solution from the undissolved gum. In water, the gum will dissolve and the resin will not, but by rubbing such a drug with water the mucilage formed by the dissolved gum emulsifies the resin—also the volatile oil, if any be present—making a milky mixture. Such a mixture is formed when asafetida is rubbed with water, and since the preparation is clearly a form of emulsion, it is so termed by the pharmacopœia. Up to the revision of 1890 they were grouped with the mixtures of the pharmacopœia. Three gum-resins are now official, asafetida, gamboge, and myrrh, and of these, the first is a representative of the Umbelliferæ—that family of plants to which belong anise, fennel, coriander, and caraway.

ASAFŒTIDA—Asafetida

(Asafœt.—Gum Asafetida)

The gum-resin obtained by incising the rhizomes and roots of *Ferula Asafœtida* Linné and *Ferula fœtida* Regel and of some other species of *Ferula* (Fam. *Umbelliferæ*), indigenous to Persia and adjacent countries, and yielding not less than 60 per cent. (or if powdered 50 per cent.) of alcohol-soluble constituents.

Outline of Assay.—The drug is digested with boiling alcohol in a flask with an upright condenser for one hour; the mixture is filtered through counterpoised filters; the insoluble residue is washed with boiling alcohol and is then weighed. Should be not more than 40 per cent. of the original asafetida taken. For details see U.S.P., p. 66.

Constituents.—Resin, 65 per cent.; gum, 25 per cent.; bassorin; vanillin; volatile oil.

The resin consists of the ferulaic acid (p. 721) ester of *asaresinotannol*, $C_{24}H_{33}O_4OH$; while the oil is a mixture of sulphides, $C_7H_{14}S_2$, $C_{11}H_{20}S_2$, $C_8H_{16}S_2$, and $C_{10}H_{18}S_2$, with terpenes. Powdered asafetida is practically without value, as the amount of heat necessary to dry it drives off practically all of the volatile oil.

Medical Properties.—Antispasmodic (in hysteria), carminative. The *emulsion* (p. 262), *pills* (p. 311), and *tincture* (p. 223) are official, and the tincture is an ingredient of the popular colic cure, *Dewee's Carminative* (mixture of magnesia, asafetida and opium, N.F. (See p. 258.) As this mixture contains opium, its use is not advisable, and some physicians specify the preparation "without opium," in which case it is made exactly as per the Formulary, save that the tincture of opium is omitted.

Dose.—Of drug, 250 milligrammes (4 grains).

CAMBOGIA—Gamboge

(Cambog.—Pipe Gamboge)

A gum-resin obtained from *Garcinia Hanburii* Hooker filius (Fam. *Guttiferæ*).

Constituents.—Gum, 16 per cent.; resin, 77 per cent. The resin consists of three *garcinolic acids*. The alpha and gamma varieties have the formula $C_{22}H_{27}O_4COOH$; while the beta acid is $C_{24}H_{34}O_4COOH$. The resin on fusion yields phloroglucin and fatty acids.

Medical Properties.—Hydragogue cathartic. Always in combination, since it is very drastic. An ingredient of *compound cathartic pills* (p. 312).

Dose.—125 milligrammes (2 grains).

MYRRHA—Myrrh

(Myrrh.—Gum Myrrh)

A gum-resin obtained from one or more species of *Commiphora* (Fam. *Burseraceæ*).

Constituents.—Gum, 60 per cent.; resin, 30 per cent.; volatile oil, 6 to 7 per cent.

The resin consists of α and β *Myrrhols* $C_{17}H_{24}O_8$ and $C_{19}H_{28}O_4$ respectively; of α and β *Myrrholols*, $C_{30}H_{44}O_{14}$ and $C_{29}H_{36}O_{10}$ respectively; and of a resene $C_{26}H_{46}O_4$. The gum hydrolyses to galactose, arabinose and xylose. The volatile oil appears to be closely related to the resene. Bolton claims that the antiseptic activity of myrrh is due to *burserazin*, $C_{20}H_{28}O_8$, which he states possesses radio-active properties.

Medical Properties.—Carminative. The official *tincture* (p. 230) is a useful addition to mouth-washes.

Dose.—500 milligrammes (8 grains).

Ammoniac, the gum-resin from *Dorema Ammoniacum*, was dropped in the eighth pharmacopœial revision. It is a stimulant, and given in doses of 15 grains.

The following drugs are said to owe their activity to resinous matter not associated with volatile oil.

Phytolacca (U.S.P. VIII; N.F. IV), or *poke root*, is the dried root of *Phytolacca decandra* Linné (Fam. *Phytolaccaceæ*), collected in autumn. It contains resin, tannin, a glucoside and a volatile acid, and is used as an alterative (in rheumatism); in large doses it is emetic. Dose as alterative is 1½ grains, as emetic is 15 grains.

Poke berries, the fruit of *Phytolacca decandra*, were formerly official. They are emetic and cathartic, and of supposed value in reducing superfluous flesh. *Dose*, 15 grains.

Gossypii Cortex (U.S.P. VIII; N.F. IV) is the dried bark of the root of *Gossypium herbaceum* Linné, or of other cultivated species of *Gossypium* (Fam. *Malvaceæ*).

It contains a volatile oil, acids (dihydroxy-benzoic, and salicylic), phenols, betaine, fat, and sugar. It is used as an emmenagogue, and should not be sold indiscriminately, being frequently used to produce abortion. It is used as an emmenagogue and ecbolic, in 30-grain doses.

NEUTRAL PRINCIPLES AND DRUGS CONTAINING SAME.

SANTONINUM—Santonin

(Santonin.)

The inner anhydride or lactone [$C_{15}H_{18}O_3$ = 246.14] of santonic acid obtained from *Artemisia pauciflora* (Ledebour) Weber (Fam. *Compositæ*). Preserve it in well-closed containers, protected from light.

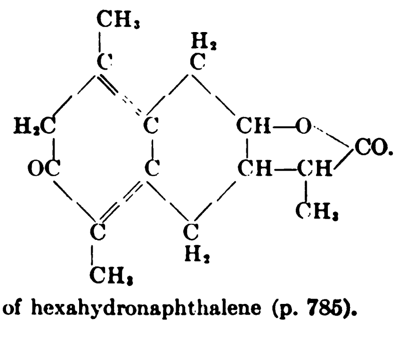
Summarized Description.

Colorless, shining flattened rhombic prisms or crystalline powder; first tasteless, then bitter; becomes yellow on exposure to light; discolored samples recrystallize white from alcohol; soluble in about 5300 parts of water, and in about 34 parts of alcohol; also soluble in chloroform and ether; solutions are lævorotatory; melts between 161° and 171°C. For details see U.S.P., p. 366.

For *tests for identity*, for *impurities:* Carbonizable organic matter (does not color sulphuric acid more than yellow). Alkaloids (acidulated aqueous filtrate, not precipitated by alkaloidal reagents) see U.S.P.

Extraction.—The drug is mixed with slaked lime and after drying and grinding, the alkaline mixture is percolated with warm alcohol. The alcohol is distilled from the percolate and to the residue, hydrochloric acid is added. After the acidulated liquid is allowed to stand five days the crystals of santonin are collected and purified.

Composition.—According to Cannizzaro, santonin is—



that is, a derivative of hexahydronaphthalene (p. 785).

Remarks.—The change to yellow on exposure to light is said to be due to its conversion into *photosantonic acid*, $C_{15}H_{22}O_5$. This explains the importance of keeping santonin and its preparations in a dark place.

Medical Properties.—Anthelmintic should be used with caution, since it has been known to produce blindness. Usually administered in the form of the troches (p. 322).

Dose.—60 milligrammes (1 grain).

Santonica (U.S.P. VIII), or *Levant wormseed*, is the dried unexpanded flower-heads of *Artemisia pauciflora* (Ledebour) Weber (Fam. *Compositæ*). Santonica contains santonin (2 per cent.), and volatile oil (2 per cent.). The volatile oil consists of *cineol* (p. 735) and *cajuputene* (or *cinene*).

Santonica is one of the two drugs called "wormseeds," and neither are seeds. The other wormseed, chenopodium, is a fruit, while santonica is a tiny cluster of unopened flowers. The two are readily distinguished by rubbing the specimen between the thumb and forefinger. If chenopodium, a little chaff rubs off, leaving a minute black seed; if santonica, the entire specimen rubs into dry, chaffy scales. Santonica is important as the source of santonin.

It is rarely used as a drug, but when so employed as an anthelmintic, its dose is 30 grains.

ELATERINUM—Elaterin

(Elaterin.)

A neutral principle obtained from Elaterium, a substance deposited by the juice of the fruit of *Ecballium Elaterium* (Linné) A. Richard (Fam. *Cucurbitaceæ*).

Summarized Description.

Minute, white, hexagonal scales or prismatic crystals; slightly acrid bitter taste; insoluble in water; soluble in about 262 parts of alcohol; also soluble in chloroform, ether and benzene. For details see U.S.P., p. 132.

For *impurities:* Carbonizable matter and alkaloids (like the tests given under santonin) see U.S.P.

Color Tests.—Crimson, then scarlet when treated with phenol and then with sulphuric acid. Brown with sulphuric acid and formaldehyde. For details see U.S.P., p. 132.

Composition.—Power and Moore state that the commercial elaterin is a mixture. One of the constituents α-elaterin, $C_{28}H_{37}O_7$, is levogyrate; while the physiologically active constituent, β-elaterin, $C_{28}H_{38}O_7$, is dextrogyrate.

Remarks.—Elaterin, according to the pharmacopœia, is "a neutral principle, obtained from elaterium." This, in turn, is a constituent of the juice of the squirting cucumber, *Ecballium Elaterium*, which is a plant belonging to the gourd family. The pronunciation of the two words is different, the accent in the official name being on the second syllable (e-*lat*-er-in), while in the other word it is on the third syllable (el-a-*ter*-i-um).

Medical Properties.—Hydragogue cathartic. Usually administered in the form of the official *triturate* (p. 295).

Dose.—Of elaterin, 3 milligrammes (1/20 grain).

Picrotoxin, $C_{15}H_{16}O_6$, which was formerly official, is the active principle of *fish-berries* (*Animirta paniculata*). It is now supposed to be a mixture of picrotoxinin, $C_{14}H_{16}O_6$, and picrotin, $C_{15}H_{18}O_6$. It is a dangerous poison, and is used chiefly for killing body-vermin. Its dose is 1 milligramme (1/64 grain).

TARAXACUM—Taraxacum

(Tarax.—Dandelion)

The dried rhizome and roots of *Taraxacum officinale* Weber (Fam. *Compositæ*). Preserve the thoroughly dried drug in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Brown, amorphous, bitter principle; resinous matter; inulin; choline; levulose; acids (hydroxy-phenylacetic, etc.); trace of volatile oil.

The resin is a combination of phytosterols (taraxasterol, cluytianol, etc.) with fatty acids (palmitic, melissic, oleic, etc.). Taraxacin and taraxacerin of older writers are mixtures.

Remarks.—Taraxacum is the root of that common weed, the dandelion. The latter synonym comes from the French "dent de lion," the lion's tooth, so termed after the jagged edges of its leaves. It is a good remedy in liver trouble. Look out for prescriptions containing fluidextract of taraxacum and nitrohydrochloric acid. Both are valuable hepatic stimulants, but when mixed they are apt to explode (p. 950).

The drug should be collected in the autumn. This is because the young root collected in the spring contains little or no bitter principle and much sugar. During the summer the latter is converted into the inulin found in the official drug.

Medical Properties.—Hepatic stimulant and digestive. Official preparations: the *extract* (p. 280) and *fluidextract* (p. 245).

Dose.—10 grammes (2½ drachms).

Apocynum (U.S.P. VIII; N.F. IV), or *Canadian hemp*, is the dried rhizome of *Apocynum cannabinum* Linné (Fam. *Apocynaceæ*). It contains *apocynin* or acetovanillin, $C_9H_{10}O_3$; *cynotoxin*, $C_{20}H_{28}O_6$ (a powerful heart stimulant, resembling Kiliani's digitic acid); resin, and tannin. It is used as a cardiac tonic and diuretic in 12-grain doses. It is by no means innocuous and should be given only under the supervision of a physician.

CALUMBA—Calumba

(**Calumb.**—Columba—Columbo—Colombo)

The dried root of *Jateorhiza palmata* (*Lamarck*) Miers (Fam. *Menispermaceæ*).

Constituents.—*Columbin; columbic acid;* three alkaloids, *columbamarine*, *jateorhizine*, and *palmitine;* starch; no tannin.

Columbin is a bitter principle, to which several formulas have been assigned by different investigators. Frey says it is $C_{27}H_{28}O_9$, and is a lactone. On treatment with alkali it yields columbic acid, $C_{28}H_{32}O_{10}$. The three alkaloids resemble berberine, and give the drug its yellow color.

Medical Properties.—Simple bitter. The *tincture* (p. 224) is official.

Dose.—2 grammes (30 grains).

PODOPHYLLUM—Podophyllum

(**Podoph.**—Mandrake.—May Apple Rhizome)

The dried rhizome and roots of *Podophyllum peltatum* Linné (Fam. *Berberidiaceæ*), yielding not less than 3 per cent. of resin.

Constituents.—*Picropodophyllin; picropodophyllinic acid; podophyllinic acid;* green oil; resin; starch, etc.

Picropodophyllin is a bitter principle, $C_{23}H_{24}O_9 2H_2O$, while picropodophyllinic acid has the formula $C_{20}H_{24}O_9$, and is physiologically inactive. The two combine to form *podophyllotoxin*.

Podophyllum is the rhizome of an American plant commonly called *may apple*, or *mandrake*. It yields that important purgative, podophyllin, which is official under the name of *resin of podophyllum* (p. 282), since it is not a definite chemical, but a mixture of the active principles of the drug, cited above, associated with resin. Too great stress cannot be laid on the difference between *podophyllum*—the rhizome—and *podophyllin*—the trade name for resin.

Medical Properties.—Hydragogue cathartic. Usually administered with other purgatives. Official preparations. The *resin* (cited above) and the *fluidextract* (p. 244).

Dose.—No dose is given in the present pharmacopœia. In the eighth edition it was stated as 500 milligrammes (7½ grains).

QUASSIA—Quassia

(Quass.—Bitter Wood)

The wood of *Picrasma excelsa* (Swartz) Planchon, known in commerce as Jamaica Quassia, or of *Quassia amara* Linné, known in commerce as Surinam Quassia (Fam. *Simarubaceæ*).

Constituents.—Quassin, picrasmin, mucilage, resin, etc.

Remarks.—Quassia is the wood of the tree, *Picrasma excelsa*, and its bitterness is well known. Its use in the form of drinking-cups was quite popular some years since, but is no longer in vogue.

Medical Properties.—Bitter tonic. The *tincture* (p. 231), is official.

Dose.—500 milligrammes (8 grains).

SANTALUM RUBRUM—Red Saunders

(Santal. Rub.)

The heart-wood of *Pterocarpus santalinus* Linné filius (Fam. *Leguminosæ*).

Constituents.—*Santalin* (or *santalic acid*), $C_{15}H_{14}O_5$, a red coloring principle.

Medical Properties.—Used entirely as coloring agent, and employed for this purpose in *compound tincture of lavender* (p. 229).

Euonymus (U.S.P. VIII; N.F. IV), or *wahoo bark*, is the dried bark of the root of *Euonymus atropurpureus* Jacquin (Fam. *Celastraceæ*). It contains euonymol, $C_{21}H_{30}O_4$, resinous matter; volatile oil (trace), dulcit, sugar, tannin, etc. The resin consists of phytosterols (euonysterol, citrullol, etc.) and fatty acids (palmitic, cerotic, oleic, etc.). No glucosides are present. Euonymus is used as a laxative and diuretic in 8-grain doses.

Cusso (U.S.P. VIII), or *Kousso*, is the dried panicles of the pistillate flowers of *Hagenia abyssinica* (Bruce) Gmelin (Fam. *Rosaceæ*). It contains resinous principle, $C_{23}H_{30}O_7$, called *tænin*, or *kosin;* tannin, etc.

The last pharmacopœia defined this drug as "the dried panicles of the pistillate flowers." A panicle is a special form of flower cluster, while pistillate flowers are those containing the pistils or female organ and no stamens.

Each perfect flower has stamens, or male organs, which produce the pollen, and a pistil or pistils, which are fertilized by or absorb the pollen and which develop within their ovaries, the seeds. In some plants the male and female organs—the stamens and pistils respectively—are not found in the same flower, in which event the flowers containing the stamens are called the staminate flowers, while the flowers containing the pistils are called the pistillate flowers. The drug, cusso, consists of the latter form of flower cluster.

Cusso is used as a tenifuge. It is usually administered in the form of an unstrained infusion, it being claimed that the action is largely mechanical.

Dose.—240 grains.

LACTUCARIUM—Lactucarium

(Lactucar.)

The dried milk juice of *Lactuca virosa* Linné (Fam. *Compositæ*).

Constituents.—*Lactucin, lactucerin, lactucic acid, lactucopicrin,* acetates of *lactucerol,* gum, resin and caoutchouc or waxy substance.

Remarks.—This drug is the dried milk juice of *Laduca virosa*, which is the wild lettuce, a plant closely allied to our garden lettuce, which, when plucked, exudes a milk juice. Such juice exuding from the wild lettuce, on drying, yields the official drug, which is a very useful sedative. Each lettuce plant naturally yields a comparatively small amount of juice, and when it is remembered that the dried juice must be scraped from each cut plant, the high price of lactucarium is explained.

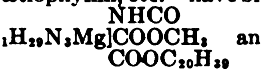
The rubbery or waxy constituent of lactucarium can be extracted with benzin, which solvent does not remove the active constituents. Hence the use of benzin in preparing the official *tincture* (p. 228).

Medical Properties.—Mildly narcotic. Useful in hacking coughs. It is said that the proprietary lactucarium preparations contain morphine. From the official *tincture* (see above) the official *syrup* (p. 198) is prepared.

Dose.—Of drug, 1 gramme (15 grains).

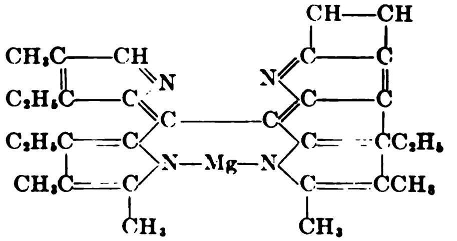
PLANT AND ANIMAL COLORS

The natural pigments found in vegetable and in animal tissue can well be discussed in this chapter, since, like neutral principles, they represent complex compounds, the structure of which are in most cases not sufficiently understood to permit their proper classification. Among these substances we find:

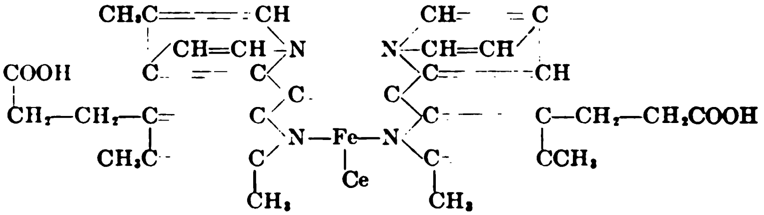


Chlorophyll and Other Leaf Pigments.—Thanks to Willstätter, the structural problems connected with chlorophyll and its allied products have been recently solved. The green color of leaves is now known to consist of four pigments: chlorophyll "a," $C_{55}H_{72}O_5N_4Mg$; chlorophyll "b," $C_{55}H_{70}O_6N_4Mg$; carotin, $C_{40}H_{56}$; and xanthophyll, $C_{40}H_{56}O_2$. The first two are green, while the last two are yellow. No less than 36 intermediate products between the two chlorophylls "a" and "b" have been prepared and analyzed by Willstätter and his pupils. These—phæophytins, phytorhodins, porphyrins, ætiophyllin, etc.—have blue, red and yellow tints. Chlorophyll "a" is supposedly $[C_{31}H_{29}N_3Mg]\overset{NHCO}{\underset{COOC_{20}H_{39}}{COOCH_3}}$ and may be considered a derivative of ætiophyllin, $C_{31}H_{34}N_4Mg$. The structure of this body is strikingly like that of hemin, the blood pigment, as comparison of the following formulas will show:

Ætiophyllin,
$C_{31}H_{34}N_4Mg$,



Hemin,
$C_{33}H_{32}O_4N_4FeCl$.

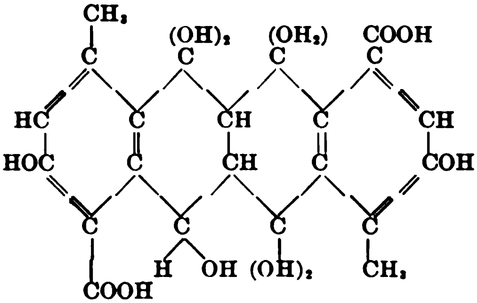


Floral Colors, or *anthocyans,* are glucosides that hydrolyze to sugar and anthrocyanidins. Willstätter has isolated three of the latter, *cyanidin, pelagonidin, delphinidin,* and has shown that they are complex naphthalin derivatives.

Hematin, the blood pigment, is described on page 844; while the structure of its halogen compound *hemin* is given above.

Carotin and **Xanthophyll,** the yellow plant pigments, are mentioned above.

Carminic acid, $C_{22}H_{22}O_{13}$, the color of cochineal (p. 850) is presumably



Orcein is a color obtained from cudbear which contains several other dyes, the chemical nature of which have not as yet been thoroughly studied.

Hematoxylin, $C_{16}H_{14}O_6.3H_2O$, is the coloring matter of logwood (p. 717).

Curcumin, $C_{14}H_{14}O_4$, is the coloring matter of turmeric which makes it of value in testing boric acid.

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CHAPTER XLIX

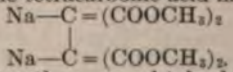
CONDENSED BENZENES AND THEIR DERIVATIVES

With the derivatives of the terpenes we close those benzene derivatives which are of interest to pharmacy, and are prepared to take up a new series of the hydrocarbons. These are found in the condensed benzenes—naphthalene and anthracene. Both of these substances are constituents of coal-tar, and are obtained by the fractional distillation of this product. The fraction distilling between 180° and 200°C. contains naphthalene, while that coming over from 340° to 360°C. contains anthracene.

Naphthalene was discovered by Garden in 1819 in coal-tar. While naphthalene is always obtained commercially from coal-tar, its synthesis has been frequently accomplished. Thus, if methane, ethylene, and acetylene be passed through red-hot tubes, one of the products of this treatment is naphthalene. Other syntheses throwing light on chemical formula are matters of passing interest. Thus if the vapor of phenyl butylene dibromide,

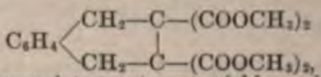
$$C_6H_5CH_2CH_2CHBrCHBr,$$

be passed over red-hot lime, naphthalene results. This synthesis is of importance as showing that naphthalene contains a benzene nucleus. Still more important is the formation of naphthalene from combination of orthoxylenen bromide, $C_6H_4{<}{\begin{smallmatrix}CH_2Br\\CH_2Br,\end{smallmatrix}}$ with the sodium salt of acetylene tetracarbonic acid methyl ester,



$$\begin{array}{l}Na{-}C=(COOCH_3)_2\\ \quad\ \ |\\ Na{-}C=(COOCH_3)_2.\end{array}$$

When they are brought together, we obtain hydronaphthalene-tetracarbonic methyl ester,

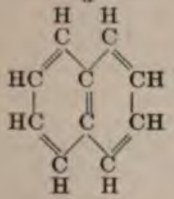


$$C_6H_4\begin{array}{l}\diagup CH_2{-}C{-}(COOCH_3)_2\\ \qquad\qquad\ |\\ \diagdown CH_2{-}C{-}(COOCH_3)_2,\end{array}$$

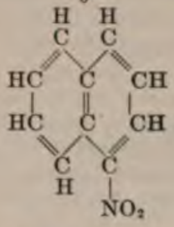
and this substance, with appropriate treatment, yields naphthalene. The importance of this synthesis is that it proves that naphthalene consists of the benzene group, attached to which is a ring containing four carbon atoms.

Two reactions of naphthalene are also of interest to use in helping to establish the formula. The first is that, on oxidation, it breaks up, yielding phthalic acid, $C_6H_4{<}\begin{matrix}COOH\\COOH\end{matrix}$; and the second is that, when treated with reducing agents, it easily absorbs four atoms of hydrogen and then with difficulty absorbs six more. All these reactions point to the following graphic formula for naphthalene (*a*):

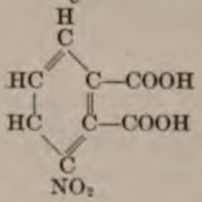
a



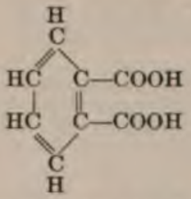
b



c



That it contains at least one benzene group is shown by the two syntheses given below. That the added ring containing four carbon atoms is in the ortho position to the benzene group is shown by the second synthesis given above, and also by the oxidation with phthalic acid. That the ring containing four carbon atoms has two double bonds is shown by the fact that it easily adds four hydrogen atoms; that the extra four carbon atoms are in a ring is shown by the behavior of its mononitro-derivative (*b*). Under certain treatment the pure benzene ring breaks, and we get nitrophthalic acid (*c*). Under other treatment it is the nitro ring that breaks, and we get pure phthalic acid,



Naphthalenum (U.S.P. VIII), or *naphthalene*, is a hydrocarbon obtained from coal tar and purified by crystallization.

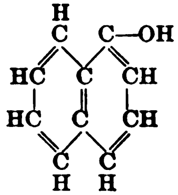
Naphthalene has been used considerably of late under the name of *coal-tar camphor*, and the popular form in which it is sold in the shape of small balls is called *moth-balls*. Its use in place of camphor is due to the increase in price of camphor which has taken place during the last decade, and not because of its greater value. It is used as an insecticide as is camphor, but there is no question as to preference of the aromatic odor of camphor to the rank, persistent odor of naphthalene. Naphthalene is also used as a carbureter of gas. Gas deficient in carbon, such as the so-called water-gas and natural gas, can be made to give a more luminous flame by passing the gas through cylinders or globes containing crystallized naphthalene. In the present day of incandescent burners the necessity of the luminous flame is lessening, and so also is the application of naphthalene as a carbureter.

Naphthalene possesses antiseptic properties, and has been recommended as a remedy in chronic bronchitis and intestinal catarrh. Its chief use, however, is externally as an antiseptic dressing, and even for this purpose it is not very popular on account of its disagreeable odor.

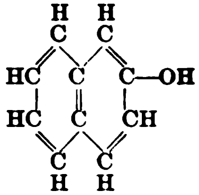
NAPHTHOLS

These are phenols of naphthalene. While there was but one phenol yielded from benzene—phenol, or carbolic acid, U.S.P.—there are two phenols from naphthalene; for, as shown in the following graphic formula, there is a difference whether the hydroxyl group is placed on the carbon atom next to the pure benzene ring or on the second carbon atom from the same. When placed on the first carbon atom, the derivative is called alpha-naphthol, whereas if placed on the second carbon atom, it is called beta-naphthol. What is true as far as alpha- and beta-naphthol are concerned is true in regard to all the mono-derivatives of the naphthols; two of each derivatives, alpha and beta, being possible.

Alpha-naphthol.



Beta-naphthol.



Both naphthols are found in coal-tar, and both can be made synthetically by treatment of naphthalene with concentrated sulphuric acid, when the naphthalene-sulphuric acid is produced. If the temperature is carefully kept at 160°C., the product will be the beta-derivative; alpha-naphthene-sulphuric acid not being produced when the mixture is heated above 80°. If this beta-derivative is fused with sodium hydroxide, betanaphthol results.

BETANAPHTHOL—Betanaphthol

(Betanaph.—Naphthol)

A monohydroxyphenol [$C_{10}H_7OH = 144.06$] of the naphthalene series. Preserve it in well-closed containers protected from light.

Summarized Description.

Colorless, or pale buff-colored shining crystalline laminæ, or white or yellowish-white crystalline powder; faint phenol-like odor; pungent taste; soluble in about 1000 parts of water and in about 0.6 part of alcohol; also soluble in chloroform, ether, glycerin, olive oil and in alkali hydroxide solutions; melts between 120° and 122°C., sublimes readily on heating. For details, see U.S.P., p. 78.

For *tests for identity*, for *impurities:* Naphthalin (completely soluble in ammonia water). Other organic matter (the ammonia solution is colored not more than pale yellow). Alphanaphthol (not colored violet by treatment with iodine and sodium hydroxide solutions), see U.S.P.

Remarks.—Betanaphthol is used as an antiseptic both internally and externally, a solution of 1 : 1000 being a good germicide. It is given internally in intestinal troubles, especially in typhoid fever.

Dose.—250 milligrammes (4 grains).

BISMUTHI BETANAPHTHOLAS—Bismuth Betanaphthol

(Bism. Betanaph.)

A compound of bismuth and betanaphthol of somewhat varying composition, yielding not less than 15 per cent. of betanaphthol [$C_{10}H_7OH$] and, upon ignition, not less than 73 per cent. nor more than 78 per cent. of bismuth oxide [Bi_2O_3].

Summarized Description.

Buff-colored to grayish-brown amorphous powder; faint odor of betanaphthol; nearly insoluble in water, alcohol, chloroform and ether; dissolved, with decomposition, by mineral acids; chars on heating and finally leaves residue of bismuth oxide. For details see U.S.P., p. 78.

For *tests for identity*, for *impurities:* Free betanaphthol (residue obtained on evaporation of chloroformic filtrate not more than 1 per cent. of original sample).

Nitrates (no ammonia vapors liberated on treatment with potassium hydroxide solution and aluminum wire).

Chloride, lead, copper, sulphate and silver (ignite, dissolve in nitric acid, precipitate as bismuth subnitrate by pouring in water, then proceed as given under bismuth subcarbonate (U.S.P., p. 81).

Arsenic (usual test) see U.S.P., p. 586.

Assay for Betanaphthol.—Dissolve the compound in hydrochloric acid with aid of heat; shake out with several portions of chloroform. Evaporate the chloroformic extracts, dry in a desiccator and weigh. Yield at least 15 per cent. of original weight of sample. For details see U.S.P.

Assay for Bismuth.—See Part V.

Remarks.—This new official chemical is prepared by precipitating a solution of sodium betanaphtholate with an acetic acid solution of bismuth nitrate. It is a popular intestinal antiseptic one commercial form of which is marketed under the name, *orphol.*

Dose.—500 milligrammes (8 grains).

Naphthol itself possesses rather irritating properties, and has a decidedly peppery taste. For that reason its application is somewhat limited, and many efforts have been made to prepare derivatives that are equally valuable as antiseptics and possessing less irritating properties. Among these derivatives are found the following:

Betol is naphthol salol or naphthol salicylate, $C_{10}H_7OOCC_6H_4OH$, and is made by treatment of the betanaphthol sodium compound with salicylic acid, in the presence of phosphorus oxychloride. The action of betol is similar to salol, except that when it enters the intestines it decomposes into naphthol instead of phenol.

Betol is given in doses of 1 Gm.

Alphanaphthol.—This naphthol derivative is said to act as a germicide in the proportion of 1 : 4000, and is also said to be one-third as poisonous as is betanaphthol. *Dose.*—1 Gm.

Benzonaphthol.—This is betanaphthol benzoate, and is, therefore, the benzoic acid ester of naphthol, and is prepared by combining naphthol with benzoyl chloride. It is a valuable intestinal antiseptic, and given in 1-Gm. doses.

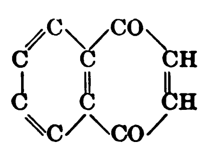
Naphtholaristol.—Di-iodo-betanaphthol. This is an iodine derivative of naphthol, and is used as an antiseptic, under the name iodonaphthol.

Hydronaphthol.—This is a proprietary naphthol derivative, said to be betanaphthol, but this statement is denied by the manufacturer, who claims it is a product of the reduction of betanaphthol.

Asaprol.—This is a calcium betanaphthol monosulphonate, $(C_{10}H_6<^{OH}_{SO_3})_2Ca$. It is sometimes called *abrastol*, and is used as an antipyretic in 0.3 to 1-Gm. doses.

Alumnol is aluminum betanaphthol disulphonate; that is, the aluminum salt of the acid, $\overset{OH}{C_{10}H_4}(SO_3H)_2$. It is used as an astringent and antiseptic, almost entirely externally.

Naphtho Quinones.—These exist in the alpha and beta forms. The alpha variety has the formula

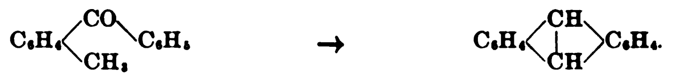


and yields several important dye-stuffs.

ANTHRACENE

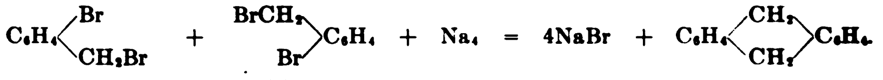
Formula, $C_{14}H_{10}$. This substance, which was discovered by Dumas and Lamant in 1835, is of importance in pharmacy only because of its medicinal derivatives. The substance itself is found in coal-tar, and is obtained from same by fractional distillation. It can also be made by passing simple organic substances, such as methane, ethylene, or alcohol, through red-hot tubes.

Three syntheses of anthracene are worthy of mention as establishing the structural formula of the body. The first synthesis is its production, by treatment of orthotolyl-phenyl-ketone, with zinc-dust. This reaction is best shown by the following graphic equation:



$$C_6H_4\left\langle\begin{matrix}CO\\CH_2\end{matrix}\right\rangle C_6H_5 \rightarrow C_6H_4\left\langle\begin{matrix}CH\\|\\CH\end{matrix}\right\rangle C_6H_4.$$

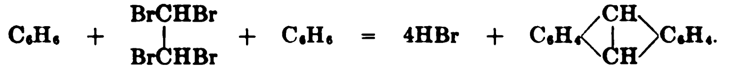
It can also be made from orthobrombenzyl bromide, treating same in ethereal solution with sodium, thus removing the bromine, with the formation of hydroanthracene:



$$C_6H_4\left\langle\begin{matrix}Br\\CH_2Br\end{matrix}\right. + \left.\begin{matrix}BrCH_2\\Br\end{matrix}\right\rangle C_6H_4 + Na_4 = 4NaBr + C_6H_4\left\langle\begin{matrix}CH_2\\CH_2\end{matrix}\right\rangle C_6H_4.$$

And this, when treated with an oxidizing agent, yields anthracene.

A third synthesis of anthracene is by treating benzene with tetrabromethane in the presence of aluminum chloride, as is shown in the equation given below:



$$C_6H_6 + \begin{matrix}BrCHBr\\|\\BrCHBr\end{matrix} + C_6H_6 = 4HBr + C_6H_4\left\langle\begin{matrix}CH\\|\\CH\end{matrix}\right\rangle C_6H_4.$$

It may be recalled that naphthalene, when treated with nascent hydrogen, easily added four atoms of hydrogen, and with difficulty six more were persuaded to go on. Anthracene, likewise, easily adds four atoms of hydrogen, and under additional treatment it can be made to take up ten extra atoms of hydrogen, this seeming to point to the existence of seven double bonds, two of which are more easily replaceable than the other five.

The structure of anthracene is deduced from the following considerations:

First, it must possess two benzene rings, this being proved by the synthesis of orthotolylphenyl ketone and by the hydroanthracene synthesis.

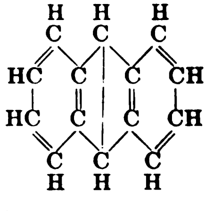
Secondly, the middle ring proceeds from the ortho position of both benzenes; this being proved by the synthesis with orthobrombenzyl bromide.

Thirdly, the middle ring has an ethylene bond extending between its two individual carbon atoms; this is shown by the hydro-anthracene synthesis.

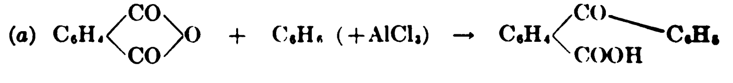
Fourthly, this ethylene bond is weaker than the others, as shown by the ease with which the two hydrogens are added.

Fifth, that each of the two benzene rings have three ethylene bonds; this being proved by the fact that the body absorbs ten other atoms of hydrogen, but that with more difficulty than did the first two.

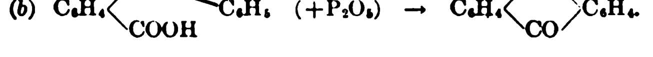
From these facts the characteristic formula of anthracene, shown below, is deduced:



Anthraquinone.—Formula, $C_{14}H_8O_2$. This is an anthracene derivative in which two hydrogen atoms have been replaced by two oxygen atoms. It is made by the treatment of phthalic acid anhydride with benzene in the presence of aluminum chloride, this yielding orthobenzoyl benzoic acid, which substance is converted into anthraquinone when treated with phosphorus pentoxide:

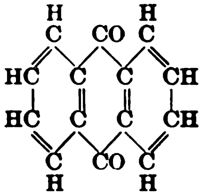


$$(a)\ C_6H_4\left\langle\begin{matrix}CO\\CO\end{matrix}\right\rangle O + C_6H_6\ (+AlCl_3) \rightarrow C_6H_4\left\langle\begin{matrix}CO\\COOH\end{matrix}\right. \!\!-\!\!C_6H_5$$

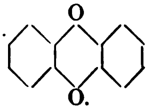


$$(b)\ C_6H_4\left\langle\begin{matrix}CO\\COOH\end{matrix}\right. \!\!-\!\!C_6H_5\ (+P_2O_5) \rightarrow C_6H_4\left\langle\begin{matrix}CO\\CO\end{matrix}\right\rangle C_6H_4.$$

This reaction led to the conclusion that the graphic formula of anthraquinone is

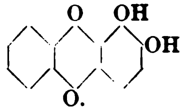


or, schematically,



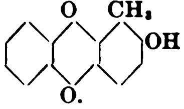
Anthraquinone can also be made by the oxidation of anthracene with chromic acid.

Anthraquinone is of little importance in pharmacy, but the oxyderivatives of it are worth more than passing notice. Among these we find *alizarine*, which is *dioxyanthraquinone:*



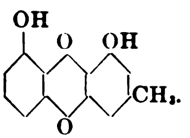
This substance, which is a coloring constituent of madder, was isolated from that dye-stuff by Graebe and Lieberman in the year 1867, while in 1879 they accomplished its synthesis by treating phthalic acid anhydride with pyrocatechin. *Madder* is the ground root of *Anchusa tinctoria*, and formerly one of the staple dyeing materials was an infusion of this substance, which yielded, in the presence of aluminum salts, characteristic scarlet dyes. The madder industry represented an important item in the agriculture of southern France until the discovery of synthetic alizarine, since which time the industry has been practically ruined. The French government, however, still directs the use of the natural dye for the red trousers of its soldiers; so some little continues to be produced for this purpose.

Oxy-methylanthraquinone,



This substance was discovered by Tschirch in his valuable researches of the active principles of the well-known purgative resins, and considered by him as the fundamental purgative principle.

Dioxymethylanthraquinone, or *chrysophanic acid,*

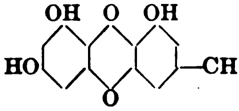


This substance represents an active purgative principle of chrysarobin, senna, rhubarb, cascara sagrada. Note that this is not the chrysophanic acid of commerce, that name being erroneously applied to the natural product which the pharmacopœia calls chrysarobin (p. 793).

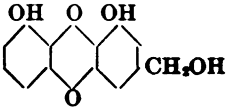
Trioxymethylanthraquinone, or *emodin*. This is one of the important purgative principles found in rhubarb, frangula, and aloes.

According to Oesterle, the emodins from these three sources are not identical, differing in the exact location of the methyl and hydroxyl groups. Thus rhubarb emodin he considers as having formula I (below) while aloe-emodin he thinks, has formula II.

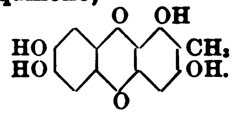
I



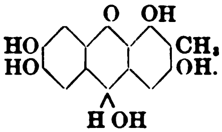
II



Tetraoxymethylanthraquinone,

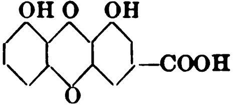


Tetraoxymethylanthraquinone is called *aloexanthin*, being one of the less important constituents of aloes. Aloin, according to Tschirch, is a body having the following graphic formula:



although commercial aloin is usually a glucosidal mixture, or, as the U. S. P. states it, "a mixture of pentosides."

Dioxycarboxyanthraquinone, or *rhein*,



is an important constituent of rhubarb.

DRUGS CONTAINING THE ANTHRAQUINONE PURGATIVES

RHEUM—Rhubarb

The rhizomes and roots of *Rheum officinale* Baillon, *Rheum palmatum* Linné, and the var. *tanguticum* Maximowicz (Fam. *Polygonaceæ*), and probably other species of *Rheum* growing in China and Thibet, deprived of most of the bark tissues and carefully dried. Preserve Rhubarb in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—Chrysophanic acid; emodin and its methyl ether; rhein, gallic acid and tannin, resin; volatile oil (trace); etc. The resin is a combination of a phytosterol, *verosterol*, with palmitic, oleic, linoleic and linolenic acids.

Remarks.—Rhubarb, one of our most valuable medicines, is the sliced and dried root of *Rheum officinale*. Study its constituents very carefully, noting that, besides the cathartic anthraquinone derivatives, it contains an astringent—rheotannic acid—and, therefore, while the drug, administered alone, has a purgative action, when combined with aromatics it acts as an astringent. This explains why aromatic syrup of rhubarb checks diarrhea, while syrup of rhubarb is a laxative.

The present pharmacopœia provides tests for the presence of emodin and of chrysophanic acid in rhubarb. The drug is heated with 1 per cent. potassium hydroxide solution; the filtrate is acidulated with hydrochloric acid and is then shaken out with ether; the yellow ethereal extract when shaken with ammonia water gives a cherry red ammoniacal layer (emodin) and a yellow ethereal layer (chrysophanic acid).

Torrefied rhubarb (p. 84) is the roasted drug. The tannin is thus destroyed, and the pure purgative results.

Medical Properties.—Cathartic and astringent (see above). Official preparations: *Fluidextract* (p. 244), *tincture* (p. 232), *aromatic tincture* (p. 232), *extract* (p. 279), *compound powder* (p. 293), and *compound pills*. The *syrup* (p. 198), is made from the fluidextract, while the *aromatic syrup* (p. 199) is made from the aromatic tincture.

Dose.—Of drug, 1 gramme (15 grains).

FRANGULA—Frangula

(Frang.—Buckthorn Bark)

The dried bark of *Rhamnus Frangula* Linné (Fam. *Rhamnaceæ*).

Constituents.—*Rhamnoxanthin* (or *frangulin*), which has been proved a mixture of *frangulinic* acid and emodin; tannin, bitter resin, etc.

Medical Properties.—Cathartic. Administered in the form of the official *fluidextract* (p. 246).

Dose.—1 gramme (15 grains).

CASCARA SAGRADA—Cascara Sagrada

(Casc. Sagr.—Rhamnus Purshiana, U.S.P. VIII)

The dried bark of the trunk and branches of *Rhamnus Purshiana* De Candolle (Fam. *Rhamnaceæ*).

Constituents.—Chrysophanic acid, emodin, bitter resins, etc.

Remarks.—Cascara sagrada is one of our most popular purgatives. Its chief drawback is its bitter taste, but it has been found that the bitterness resides largely in a resinous principle, and can be removed by treatment with alkali, without seriously lessening the purgative action of the drug. This fact is applied in the manufacture of the official aromatic fluidextract, where the bark is freed from bitterness by treatment with magnesia.

Both frangula and cascara sagrada in fresh condition contain a ferment which causes griping, and which is dissociated on allowing the bark to age; hence the last pharmacopœia required that both barks be at least one year old when used. As the pharmacist can never tell whether the fluidextract purchased in the open market has been made from the green bark, the only safe course is to make his own fluidextract from bark that he has kept in stock for one year. It is claimed, however, that heating the bark for a few hours at 100°C. destroys the ferment, and that barks can, therefore, be aged in this way.

Medical Properties.—Purgative of great service. There is, however, danger of contracting the "cascara habit." The *extract* (p. 274), *fluidextract* (p. 246), and the *aromatic fluidextract* (p. 247) are official.

Dose.—1 gramme (15 grains).

SENNA—Senna

(Senn.)

The dried leaflets of *Cassia acutifolia* Delile, known in commerce as Alexandria Senna, or of *Cassia angustifolia* Vahl, known in commerce as India Senna (Fam. *Leguminosæ*), without the presence or admixture of more than 10 per cent. of stem tissues, pods, seeds and other impurities.

Constituents.—*Rhein*, *aloe-emodin* and their glucosides; *kæmferol* (a trihydroxy-flavenol) and its glucoside; volatile oil (trace); resins; salicylic acid; etc.

The resins are combinations of a phytosterol and a phytosterolin, with fatty acids (palmitic, stearic, etc.). Cathartic acid, of older investigators is now known to be a mixture. The ash of Tinnevelly senna contains considerable magnesium. Alexandrian senna has the same constituents as Tinnevelly except it contains some iso-rhamnetic acid and no magnesium.

Remarks.—Senna represents the leaflets of two plants, *Cassia acutifolia* being the source of the drug shipped from Egypt, and *Cassia angustifolia* yielding that exported from India. *Tinnevelly Senna* is a fine variety coming from India. Strong alcohol removes the griping, resinous principle without extracting the true purgative constituent, and this idea was employed in the recipe for the fluidextract given in the last pharmacopœia.

Medical Properties.—Cathartic. Official preparations: The *fluidextract* (p. 244) and *compound infusion* (p. 217), *syrup of senna* (p. 200) is made from the fluidextract. Senna is a constituent of *compound powder of glycyrrhiza* (p. 293) and the fluidextract is used in making *compound syrup of sarsaparilla.*

Dose.—Of drug, 4 grammes (60 grains).

ALOE—Aloes

The inspissated juice of the leaves of *Aloe Perryi* Baker, yielding Socotrine Aloes; or *Aloe vera* Linné, yielding Curaçao Aloes; or of *Aloe ferox* Miller, yielding Cape Aloes (Fam. *Liliaceæ*).

Constituents.—Aloin, emodin, resin, etc.

Remarks.—It will be noted that the official definition given above mentions three sources of aloes. The plant *Aloe vera* furnishes curaçao aloes, *Aloe Perryi* yields Socotrine aloes, while *Aloe ferox* furnishes Cape aloes. The aloins from these three varieties are not identical.

In passing it might be stated that these plants have huge succulent leaves, like those of the century plant, and that the drug is obtained by cutting these leaves from their base, allowing the juice to drain (in proper varieties the leaves are expressed), and permitting it to dry in the sun.

Medical Properties.—Laxative, purgative, emmenagogue. Official preparations: *pills* (p. 311), and *tincture* (p. 222). Aloes is also a constituent of *compound extract of colocynth* (p. 275), *compound pills of rhubarb* (p. 312) and *compound tincture of benzoin* (p. 224).

Dose.—250 milligrammes (4 grains).

Aloe Purificata (U.S.P. VIII) is aloes purified by mixing with enough alcohol to make a liquid that can be strained through a No. 60 sieve, and the strained liquid is then freed from alcohol by evaporation on a water-bath. In other words, the process is purely mechanical, the object being to free crude aloes from dirt, straw, and other insoluble impurities. In the past, commercial aloes was so impure that purification was imperative, but thanks to the pure food and drug law and the more rigid inspection of drugs as they pass through the ports of entry, the quality of aloes has greatly improved.

ALOINUM—Aloin

(Aloin.)

A pentoside or mixture of pentosides obtained from aloes, varying in chemical composition, physical and chemical properties according to the source. Preserve it in well-closed containers, protected from light.

Summarized Description.

Micro-crystalline powder or minute acicular crystals; color lemon yellow to dark yellow; not more than faint odor of aloes; intensely bitter taste; darkens on exposure to light and air; soluble in water, alcohol and acetone; slightly soluble in ether. For details see U.S.P., p. 38.

For *tests for identity*, for *impurities:* Emodin (benzene solution gives no more than faint pink color to ammonia water) see U.S.P.

Composition.—The chemistry of this body has been already discussed (p. 790).

Manufacture.—Aloes is treated with acidulated water hot, and the infusion allowed to stand a day; the clear liquid is decanted from the sediment, concentrated at low heat, and set in a cool place, when the aloin will separate in minute crystals. This crude aloin is then purified by recrystallization from hot water. It is also made by treating an acid infusion of aloes with alkali and solution of calcium chloride. A combination of aloin with calcium is effected, and this separates out, the calcium being eventually removed by solution in diluted hydrochloric acid. The mixture is then treated with hot water, in which the resulting calcium chloride is very soluble, while the less soluble aloin crystallizes from the solution on cooling.

Remarks.—While in the last pharmacopœia the aloin from Curaçao aloes was given the preference, in the present edition, any of the several aloins can be employed. Hence there has been omitted Histed's test, that well-known reaction based upon the behavior of the several forms of aloin when treated with concentrated nitric acid. With this reagent Curaçao aloin turns cherry red; nataloin (that from Natal aloes) turns vivid crimson; Socaloin (that from Socotrine aloes) is not colored; while capaloin (that from Cape aloes) turns a permanent green.

Medical Properties.—Purgative.

Dose.—15 milligrammes (¼ grain).

CHRYSAROBINUM—Chrysarobin

(Chrysarob.)

A mixture of neutral principles extracted from Goa Powder, a substance found deposited in the wood of *Vouacapoua Araroba* (Aguiar) Druce (Fam. *Leguminosæ*). Preserve it in well-closed containers, protected from light.

Summarized Description.

Brownish to orange-yellow, micro-crystalline powder; irritating to the mucous membrane; soluble in about 4800 parts of water and in about 310 parts of alcohol; also soluble in chloroform, ether, benzene and carbon disulphide. For details see U.S.P., p. 110.

For *tests for identity*, for *impurities:* Chrysophanic acid (yellow, not violet-red, when treated with fuming nitric acid and then with ammonia water; aqueous solution not colored by a few drops of ferric chloride solution) see U.S.P., p. 111.

Constituents.—Emodin monomethyl ether, anthranol of chrysophanic acid, ararobinol, $C_{23}H_{16}O_5$, sugar, etc.

Extraction.—Chrysarobin is obtained from Goa powder by extraction with hot chloroform, evaporation of the chloroformic solution to dryness, and powdering the residue.

Remarks.—*Chrysarobin*, long and improperly called *chrysophanic acid*, is a derivative of Goa powder, a waste-product of the tree *Vouacapoua*

Araroba. While excellent for skin diseases, chrysarobin is objectionable by reason of the stain it produces.

Medical Properties.—Drastic purgative. Generally used externally in skin troubles in the form of the official *ointment* (p. 332).

Dose.—30 milligrammes (½ grain).

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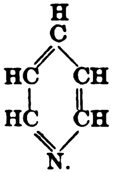
CHAPTER L

THE PYRIDINE AND QUINOLINE DERIVATIVES

It may be recalled (p. 682), that we have already considered a nitrogen compound, pyrrol, having the formula C_4H_4N. Pyridine is a ring compound similar to pyrrol, but having the formula C_5H_5N. It occurs in coal-tar, and has the disagreeable odor of bone oil.

It can be made by treating piperidine with concentrated sulphuric acid at a temperature of 300°C., piperidine, $C_5H_{11}N$, being made by heating pentamethylene-diamine hydrochloride. It can also be made from quinoline.

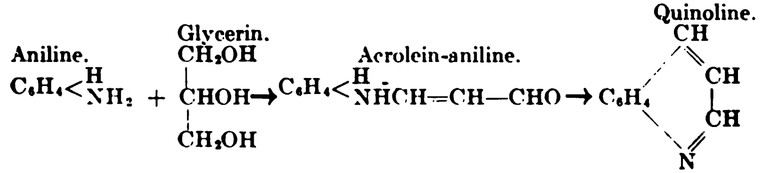
Pyridine resembles benzene in being oxidized with difficulty, and having the power to absorb six atoms of hydrogen or of any halogen. From this behavior and other reactions it is assumed that the formula of pyridine resembles that of benzene, except that in place of one of the carbon atoms in the benzine ring an atom of nitrogen is substituted, giving the graphic formula—



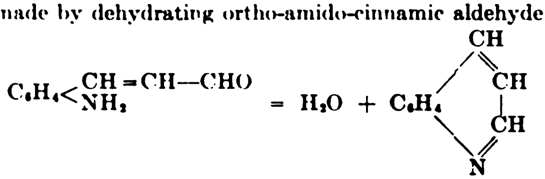
Pyridine is a colorless liquid, which, on account of its nauseating taste, is used for denaturizing alcohol—*i.e.*, for adding to alcohol which is to be used in the arts—and is, therefore, permitted to be sold without the revenue tax. The addition of the disagreeable constituent, pyridine, renders the use of such alcohol impossible as a beverage, and therefore accomplishes the purpose desired by the government. Pyridine is also used in asthma by inhalation, and is sometimes administered internally in doses of 2 to 10 minims.

Quinoline.—Formula, C_9H_7N. This substance, which is closely allied to pyridine, occurs, like it, in coal-tar and also in bone oil.

Quinoline is made by Skraup's reaction, which consists of treating aniline with glycerin in the presence of sulphuric acid and nitrobenzene.

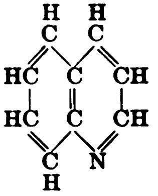

Aniline.
Glycerin.
Acrolein-aniline.
Quinoline.
$C_6H_4<^{H}_{NH_2}$ + CH_2OH | $CHOH$ | CH_2OH → $C_6H_4<^{H}_{NHCH=CH—CHO}$ → C_6H_4
CH
CH
CH
N

It can also be made by dehydrating ortho-amido-cinnamic aldehyde.



On oxidation, quinoline yields pyridine dicarbonic acid, thus showing that it has a pyridine ring in its structure. It absorbs hydrogen in a way which indicates that

not only does it possess a pyridine ring, but also a benzene ring, and to the substance is, therefore, assigned the following graphic formula:



Besides the methods of synthesis of quinoline given above, the chemical has been produced by the fusion of quinine with potassium hydroxide, and it was by this means that the compound was discovered and received its name.

ACIDUM PHENYLCINCHONINICUM—Phenylcinchoninic Acid

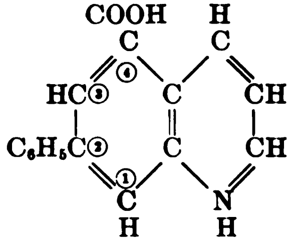
(Acid. Phenylcinch.—Phenyl-quinoline-carboxylic Acid)

An organic acid, 2-phenyl-quinolin-4-carboxylic acid [$C_{16}H_{11}NO_2$ or $C_6H_5.C_9H_5N.(COOH) = 249.10$].

Summarized Description.

Small colorless needles, or white or yellowish-white microcrystalline powder; faint odor suggesting benzoic acid; bitter taste; insoluble in cold water; slightly soluble in cold alcohol and ether. Melts at 210° with partial decomposition. For details see U.S.P., p. 20.

Remarks.—This new official synthetic is largely used under the trade name *atophan.* It is a derivative of quinoline and the figures given in the official definition represent the carbon atoms of the quinoline nucleus to which the phenyl and the carboxyl groups are attached. The graphic formula given below make this more plain.



Atophan occurs in colorless needles, melting at 210°C. It is insoluble in cold water and has a slightly bitter taste. It is used in gout, since it is supposed to increase the uric acid excretion.

Dose.—500 milligrammes (8 grains).

Novatophan is ethyl-methyl-atophan. It has the advantage over atophan of being tasteless. It is given in the same dose as atophan.

ALKALOIDS

Alkaloids are an important class of plant bases having complex composition; in fact, some chemists considering the phrase "alkaloid" as covering only those basic organic substances whose chemistry is not clearly defined. This statement, while extreme, is partially justified by the fact that, as alkaloidal bodies are studied, they are frequently assigned to other divisions of chemistry. Thus *betaine* from beets is now grouped among the derivatives of glycocol, or amidoacetic acid,

$\begin{array}{l}CH_2NH_2\\ |\\ COOH\end{array}$ (p. 604); choline from bile is classed as a derivative of tetramethyl ammonium hydroxide, $N\begin{array}{l}\equiv(CH_3)_4\\ -OH\end{array}$ (p. 670); while caffeine is now considered as a uric-acid derivative (p. 678) the pharmacopœia dropping the word "alkaloid" in discussing it, calling it "a feebly basic substance." There still remains, however, a distinct class of bodies which we can call alkaloids; the new definition for alkaloids being *nitrogenous plant bases, which are derivatives of pyridine, quinoline, or similar ringed bodies.*

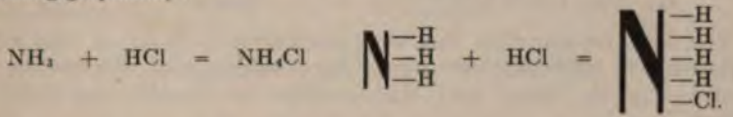
Hence it is necessary to drop the old classification of alkaloids and turn to the new, but before so doing it is advisable, from the historic point of view, to discuss a few phases of the old alkaloidal classification still dear to the present generation of pharmacists, at the same time calling attention to the fallacies found in each statement, which in most cases consist in the fact that while the statement is true for alkaloids it also applies to other substances no longer considered alkaloids.

I. "Alkaloids are basic, turning red litmus-paper blue, and combining with acids to form salts." True, but so do other bodies, such as methylamine (p. 586) and aniline (p. 694).

II. "Alkaloids are nitrogen bases, and are built on the ammonia type." True, but so are such compounds as mono-, di-, and tri-methylamine, and tetramethyl ammonium iodide (p. 574).

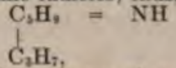
Before leaving this subject, however, it is well to employ it in order to explain why the formula of any alkaloidal salt is the formula of the alkaloid from which derived, plus the formula of the acid, *including its hydrogen.* Thus the formula of morphine hydrochloride, U.S.P. VIII, is $C_{17}H_{19}NO_3HCl$, while the formula of morphine, U.S.P. VIII, is $C_{17}H_{19}NO_3$.

We have already learned (p. 449) the formation of a salt from ammonia was different from the formation of a sodium, potassium, or any other metallic salt, the reaction being graphically:



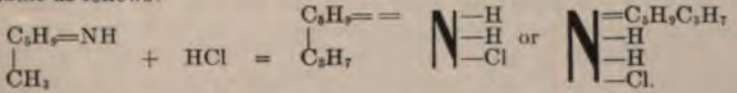
$$NH_3 + HCl = NH_4Cl \qquad N\begin{array}{l}-H\\ -H\\ -H\end{array} + HCl = N\begin{array}{l}-H\\ -H\\ -H\\ -H\\ -Cl.\end{array}$$

On this ammonia type are the alkaloids built, one, two, or all the hydrogen atoms being replaced by complex organic radicles; thus, one of the simplest, coniine, is—



$$\begin{array}{l}C_5H_9 = NH\\ |\\ C_3H_7,\end{array}$$

and just as $NH_3+HCl=NH_4Cl$, as shown above, so does coniine plus hydrochloric acid combine as follows:



$$\begin{array}{l}C_5H_9{=}NH\\ |\\ CH_3\end{array} + HCl = \begin{array}{l}C_5H_9{=}{=}\\ |\\ C_3H_7\end{array} \; N\begin{array}{l}-H\\ -H\\ -Cl\end{array} \text{ or } N\begin{array}{l}=C_5H_9C_3H_7\\ -H\\ -H\\ -Cl.\end{array}$$

Even so does the valence of the nitrogen in morphine change from III to V in the conversion of the free alkaloid into the salt. This also explains why the salt is named morphine hydrochloride (hydrochlorate, U.S.P. 1890), and not morphine chloride.

III. "There are a special line of reagents producing precipitates with alkaloids. Such alkaloidal precipitants are Mayer's reagent (potassio-mercuric iodide,) gold chloride, tannic acid, etc." True, but these same reagents precipitate almost any amido derivative.

IV. "Alkaloids are grouped into the amines (liquid alkaloids) and the amides (solid alkaloids)." By amines we mean those bodies having the general formula RNH_2 (p. 573), while amides are those bodies having the general formula $RCONH_2$—that is, where the hydroxyl of the carboxyl group is replaced by the NH_2 group. The statement that the solid alkaloids are amides is not wholly true, as the solid alkaloids, atropine, cocaine, and morphine, do not contain the $RCONH_2$ group.

Alkaloids are either solid or liquid, the greater number of them being solid. Among the liquid alkaloids that might be mentioned are nicotine, coniine, and lobeline. No fixed rule can be given as to the difference in the structure between the solid and the liquid alkaloids; the general statement that the liquid alkaloids are free from oxygen is not always true. Thus, the liquid alkaloid pelletierine contains oxygen.

Alkaloids usually occur in the form of salts, the most abundant natural alkaloidal combinations being citrates, malates, and tannates. The alkaloids found in cinchona are generally salts of quinic acid, while the alkaloids of opium are usually combined in the drug with meconic acid. So far, very few alkaloids have been found in monocotyledonous plants, the only two of importance derived from plants of that order being colchicine and veratrine, the greater majority of the alkaloids being found in the plants of the diocotyledonous series, although curious to relate, two of the most important families of this group, the two containing the largest number of species, namely, the natural orders Compositæ and Labiatæ, contain no alkaloids. On the other hand, with some plant families, such as the Solanaceæ and Papaveraceæ, almost every represented species contains alkaloids.

As to nomenclature, note that the pharmacopœia reserves the termination "ine" for alkaloids only, using "in" for glucosides and neutral principles. Other countries do not make this distinction, terminating the names of all active principles of drugs with "in." For comparison, let us tabulate the pharmacopœial Latin and English names of a typical glucoside and a typical alkaloid:

	LATIN	ENGLISH
GLUCOSIDE, U.S.P. VIII	Salic*inum*.	Salic*in*.
ALKALOID, U.S.P. VIII	Quin*ina*.	Quin*ine*.
ALKALOID, U.S.P. 1870	Quinia.	

The last termination has still considerable hold in the Southern States, where there are often calls for "sulphate of cinchonidia" (now cinchonidina in Latin, and cinchonidine in English) or for "quinia sulphas."

EXTRACTION OF ALKALOIDS

On no subject in pharmacy does there seem to be less information of recent character, than there is as far as the commercial extraction of alkaloids is concerned. This is partly due to the diversity of methods that may be employed for each drug; as well as the fact that modern alkaloidal plants keep their processes secret. So it is that while an outline of extraction is given under each alkaloid discussed on the pages which follow most of these methods are those published by earlier writers.

In attempting to give a general outline of the way that alkaloids are obtained, it may be said that the drug is first extracted with acidulated water or alcohol. If the latter menstruum is used, the alcohol is distilled off and the residue taken up with acid, and this acidulated aqueous liquid is made alkaline with potassa, soda, ammonia, or milk of lime—thereby liberating the alkaloid which precipitates from solution. The freed alkaloid is either collected on a filter and purified by recrystallization from the appropriate solvent or more generally while still in the liquid is "shaken out" (p. 140) with a solvent immiscible in water—say gasoline, petroleum ether, chloroform, or ether. The freed alkaloid dissolves in this solvent, the solution separated from the now exhausted aqueous layer, the solvents evaporated off, and the crude alkaloid purified by recrystallization, usually as a salt rather than as the free alkaloid. Of course, this bare outline omits the details of purification employed in each case, these details being taken up in discussing the individual drugs.

CLASSIFICATION OF ALKALOIDS

Pyridine derivatives:
- Piperidine.
- Piperine.
- Coniine.
- Pilocarpine, U.S.P.
- Nicotine.
- Sparteine, U.S.P.

Tropine derivatives:
- Tropine.
- Atropine, U.S.P.
- Homatropine, U.S.P.
- Scopolamine, U.S.P.
- Hyoscine.
- Hyoscyamine, U.S.P.
- Cocaine, U.S.P.
- Beta-eucaine, U.S.P.

Quinoline derivatives:
- Quinine, U.S.P.
- Quinidine.
- Cinchonine, U.S.P.
- Cinchonidine, U.S.P.
- Phenylcinchoninic acid, U.S.P.
- Strychnine, U.S.P.
- Veratrine, U.S.P.

Isoquinoline derivatives:
- Isoquinoline.
- Hydrastine, U.S.P.
- Hydrastinine, U.S.P.

Phenanthrene derivatives:
- Morphine, U.S.P.
- Diacetyl-morphine, U.S.P.
- Ethyl-morphine, U.S.P.
- Apomorphine, U.S.P.
- Codeine, U.S.P.

Unallotted:
- Physostigmine, U.S.P.
- Aconitine, U.S.P.
- Colchicine, U.S.P.
- Pelletierine, U.S.P.
- Emetine, U.S.P.
- Cornutine.

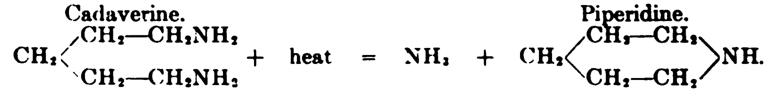
The other alkaloids, such as *gelsemine*, *cissampeline*, etc., are but little understood.

Note.—In the table just given, alkaloids to which the initials "U.S.P." are appended are official either as free alkaloid or as a salt. In other words, it does not necessarily mean that the free alkaloid is official, nor that none of its salts is official.

GROUP I.—THE PYRIDINE DERIVATIVES

The chemistry of pyridine has already been considered on p. 795. Its hydrogen compound, *hexahydropyridine*, $C_5H_{11}N$, is called *piperidine*, and was discovered by Rochleder in 1849 on heating piperine with soda lime.

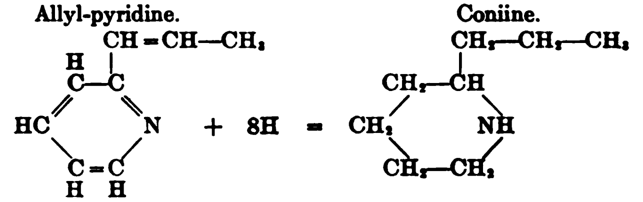
Piperidine is obtained from *cadaverine* (or *pentamethylene diamine*), a substance found in decaying flesh. On heating this body ammonia is driven off, with the formation of piperidine, as shown below:



$$CH_2\left\langle\begin{matrix}CH_2-CH_2NH_2\\CH_2-CH_2NH_2\end{matrix}\right. + \text{heat} = NH_3 + CH_2\left\langle\begin{matrix}CH_2-CH_2\\CH_2-CH_2\end{matrix}\right\rangle NH.$$

Piperidine is here mentioned not because of its value in pharmacy, but because its propyl derivative is an alkaloid of importance by reason of being the first alkaloid made synthetically. This alkaloid is coniine. *Coniine* was isolated by Giesecke in

1827 from the fruit of *Conium maculatum*. It is alpha-propyl-piperidine, and its synthesis was accomplished by Ladenberg in 1886 by reduction of allyl-pyridine:

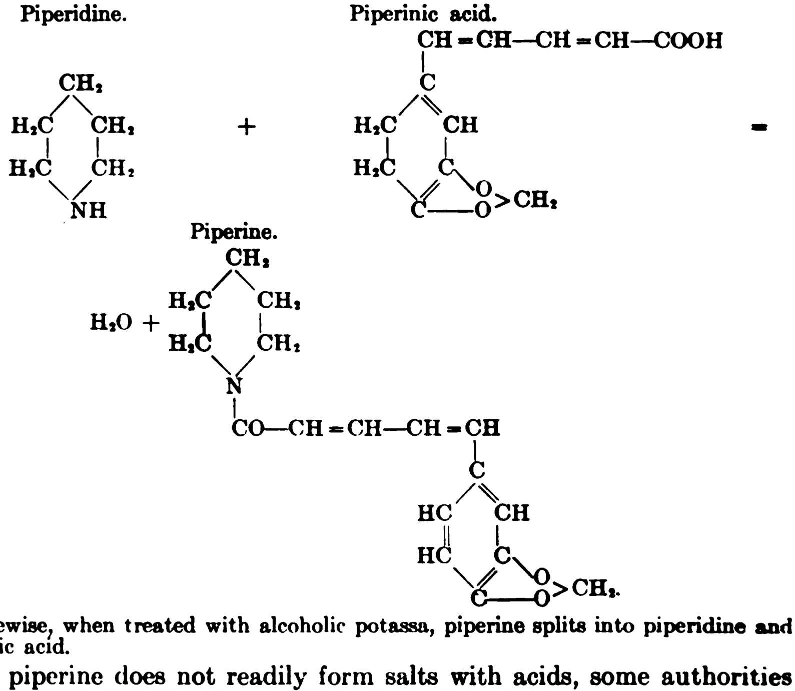

Allyl-pyridine. Coniine.

Synthetic coniine is identical with the natural product obtained from conium, except that it is optically inactive, while the natural coniine is dextrogyrate. As already mentioned on p. 615, when an inactive form of an optically active chemical is known, it usually consists of equal quantities of the dextrogyrate and the lævogyrate forms of this substance. Following this theory, the inactive synthetic coniine must be a mixture of the dextrogyrate and the lævogyre alkaloid. Now, if the natural coniine is the dextrogyre, while the artificial is a mixture of the dextrogyre with lævogyre, it follows that if lævogyre is removed, the dextrogyre will remain, and by reason of this theory an effort was made to remove the lævogyrate form from the synthetic inactive product by special crystallizations, and a product exactly identical with the natural was obtained.

As mentioned above, coniine is the alkaloid found in *Conium maculatum*, and is rarely used in medicine.

Piperina (U.S.P. VIII), or *piperin*, is a feebly basic substance obtained from pepper. In preparing it, powdered pepper is boiled for fifteen minutes with milk of lime. The mixture is evaporated to dryness on a water-bath and the piperine is extracted from the residue with ether. The crude piperine is then recrystallized from alcohol.

Piperine is the combination of piperidine with piperinic acid, and has been made synthetically from these substances, viz.:

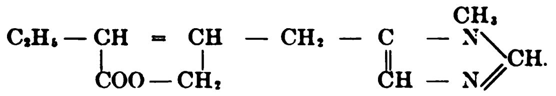

Piperidine. Piperinic acid. Piperine.

Likewise, when treated with alcoholic potassa, piperine splits into piperidine and piperinic acid.

As piperine does not readily form salts with acids, some authorities no longer consider it an alkaloid, the last pharmacopœia seeming to hold to that opinion by defining it as "a feebly basic substance."

Piperine is a useful antiperiodic, given in 3-gram doses.

Pilocarpine.—*Composition.*—The formula of pilocarpine is supposed to be—



Extraction.—Jaborandi in fine powder is moistened with sodium carbonate solution and then extracted with warm benzene. The benzene percolate containing the free alkaloid is shaken with diluted hydrochloric acid (which dissolves the alkaloid as hydrochloride), and the separated acid liquid is made alkaline with sodium carbonate solution and then shaken out with chloroform. The chloroform solution of the free alkaloid is next evaporated, the crude alkaloid taken up with diluted nitric acid, and the nitrate thus purified by recrystallization from alcohol.

The free alkaloid can be obtained from the nitrate by making its aqueous solution alkaline with ammonia, shaking out with chloroform, and evaporation of the chloroform.

The "shaking out" with chloroform will be explained in Part V, under Extraction with Immiscible Solvents.

The following salts of pilocarpine are official.

PILOCARPINÆ HYDROCHLORIDUM—Pilocarpine Hydrochloride

(Pilocarpin. Hydrochl.—Pilocarpine Chloride)

The hydrochloride ($C_{11}H_{16}O_2N_2.HCl = 244.62$) of an alkaloid obtained from pilocarpus. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless translucent hygroscopic crystals; faintly bitter taste; soluble in about 0.3 part of water, in about 2.4 parts of alcohol and in about 540 parts of chloroform; insoluble in ether; when dried, it melts between 195° and 198°C. For details see U.S.P.

Color Test.—When the proper amount of the salt is treated with solution of hydrogen dioxide solution and benzene, then shaken with potassium dichromate solution, the benzene layer turns blue and the aqueous layer is yellow.

For *tests for identity* and for *impurities:* Other alkaloids (color test just given); also no turbidity on adding to a solution, ammonia water or potassium dichromate T.S.). Readily carbonizable matter (does not color sulphuric acid more than faint yellow) see U.S.P., p. 321.

Remarks.—The color produced with sulphuric acid and potassium dichromate is quite characteristic, each alkaloid giving a different shade with the combination. In the case of pilocarpine a grass-green color is produced. The salts of pilocarpine, like the drug pilocarpus, are valuable sudorifics and sialagogues.

Dose.—By mouth, 10 milligrammes ($\frac{1}{6}$ grain). Hypodermic, 5 milligrammes ($\frac{1}{12}$ grain).

PILOCARPINÆ NITRAS—Pilocarpine Nitrate

(Pilocarpin. Nit.)

The nitrate [$C_{11}H_{16}O_2N_2.HNO_3 = 271.17$] of an alkaloid obtained from pilocarpus. Preserve it in well-closed containers, protected from light.

Summarized Description.

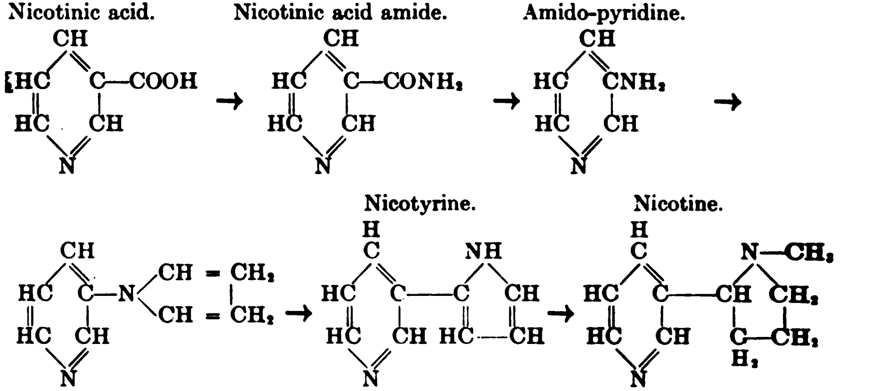
Shining crystals; soluble in about 4 parts of water; and in about 60 parts of alcohol; insoluble in chloroform and ether; melts between 170° and 173°. For details see U.S.P. Otherwise like pilocarpine hydrochloride.

For *tests for identity* and for *impurities:* Chloride (the silver nitrate test) see U.S.P., p. 322 and also Part V of this book.

Medical Properties.—Used just like the hydrochloride.

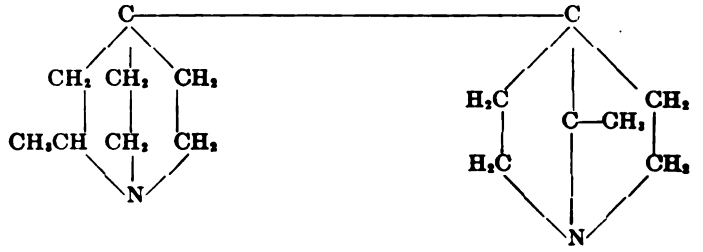
Dose.—See the hydrochloride.

Nicotine.—Nicotine was isolated from tobacco by Posselt in 1828. Investigations show that this alkaloid is piperidyl-tetrahydro-methyl-pyrrol, the graphic formula of which is given below. The structural formula was worked out by Pictet and Crepieux in 1895, whose work, however, did not lead to the synthesis of the alkaloid, but only as far as nicotyrin, the derivative of nicotine shown in the graphic formulas given below:


Nicotinic acid. Nicotinic acid amide. Amido-pyridine.

Nicotyrine. Nicotine.

Sparteine.—The structural formula of this alkaloid is supposed to be:



SPARTEINÆ SULPHAS—Sparteine Sulphate

(Spartein. Sulph.)

The sulphate $[C_{15}H_{26}N_2.H_2SO_4+5H_2O=422.39]$ of sparteine, a liquid **alkaloid** obtained from *Cytisus Scoparius* (Linné), Link (Fam. *Leguminosæ*). **Preserve it in well-closed containers, protected from light.**

Summarized Description.

Colorless rhombohedral hygroscopic crystals or crystalline powder; slightly saline, bitter taste; soluble in about 1.1 parts of water and in about 2.4 parts of alcohol; insoluble in chloroform and ether; leaves not more than 0.1 of 1 per cent. of ash. For details see U.S.P.

For *tests for identity* and for *impurities:* Readily carbonizable matter (makes colorless solution in sulphuric acid). Ammonium salts (no ammoniacal odor on gently heating with potassium hydroxide solution). Aniline (does not give the isonitrile reaction) see U.S.P., p. 401.

Extraction.—The drug is extracted with acidulated water, the liquid made alkaline with sodium hydroxide, and from this alkaline liquid the alkaloid, which is volatile, is separated by distillation. It is purified by dissolving in diluted hydrochloric acid, evaporated to dryness, and the alkaloid freed by treatment with potassium hydroxide is redistilled. The salts are made from the alkaloid by treatment with the appropriate acid.

Remarks.—Sparteine sulphate is a valuable diuretic.

Dose.—10 milligrammes (1/6 grain).

Group II.—The Tropine Derivatives

The very important alkaloids of the nightshade families are derivatives of tropine, this being an artificial alkaloid which is a decomposition product of atropine, and since its structure is similar to that substance from which it is derived, chemists consider it as the base upon which atropine is built.

The synthesis starts with a substance containing a ring of seven carbon atoms, *cycloheptene* (Fig. 1). From this the dimethyl-amido combination (Fig. 2) is prepared and this with hydrochloric acid and subsequent distillation yields *tropidine* (Fig. 3), which on treatment with caustic alkalies yields tropine (Fig. 4).

Fig. 1

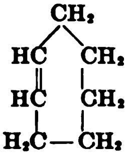


Fig. 2.

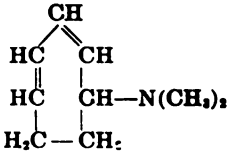


Fig. 3.

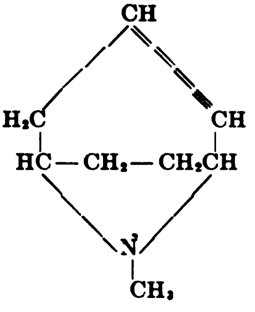
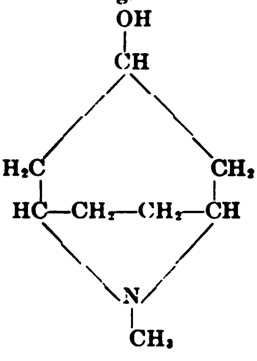
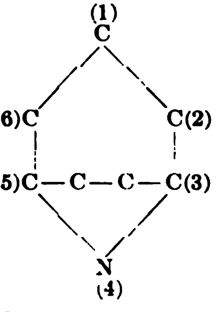


Fig. 4.



It will be seen that this synthesis starts with a ring of seven carbon atoms and by introduction of one amido group becomes a pyridine ring with a chain of two carbon atoms extending from pyridine carbon atom 3 to carbon atom 5.



ATROPINA—Atropine

(Atrop.)

An alkaloid [$C_{17}H_{23}NO_3 = 289.19$] obtained from belladonna and from some other plants of the *Solanaceæ*. Preserve it in well-closed containers, protected from light.

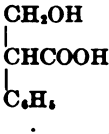
Summarized Description.

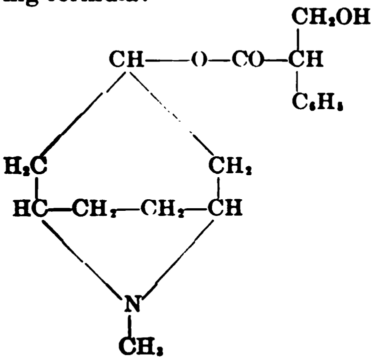
White rhombic prisms; extremely poisonous; soluble in about 455 parts of water and in about 1.5 parts of alcohol; also soluble in glycerin, chloroform and ether; melts between 114° and 116°C. For details see U.S.P.

For *tests for identity*, and for *impurities:* **Readily carbonizable matter (not colored more than faint yellow by sulphuric acid). Foreign alkaloids (acidulated solution not precipitated by platinic chloride). Apoatropine or belladonnine (acidulated solution made turbid by adding sodium hydroxide solution; but not by adding ammonia water under proper conditions see U.S.P., p. 68.**

***Extraction.*—The alcoholic percolate from belladonna is made alkaline by treatment with milk of lime and then filtered. The filtrate (a solution of free alkaloid) is acidulated with diluted sulphuric acid, freed from fat and resin by evaporation of the alcohol, and taking up with acidulated water. The acidulated aqueous filtrate is then treated with alkali, and the free alkaloid thus precipitated is washed with water, dissolved in alcohol, and crystallized from this solution by addition of a little water.**

Remarks.—Atropine is a tropine tropate, and can be made by treating tropine with tropic acid in the presence of hydrochloric acid.

Tropic acid is phenyl-hydracrylic acid,  $CH_2OH{-}CHCOOH{-}C_6H_5$ and when it is combined with tropine, the product of the union—atropine—is assumed to have the following formula:



Vitali's reaction for atropine is interesting. When the alkaloid is treated with fuming nitric acid and evaporated to dryness, and a drop of potassium hydroxide be added to the dry residue, it will give a violet-blue color, and if the residue is again covered with alcohol, the isonitril odor (p. 581), is evolved. The color-reaction part of Vitali's test is given in the present pharmacopœia.

Atropine is a sedative and mydriatic.

Dose.—5/10 milligramme (1/120 grain).

ATROPINÆ SULPHAS—Atropine Sulphate

(Atrop. Sulph.)

The sulphate $[(C_{17}H_{23}NO_3)_2H_2SO_4+H_2O=694.49]$ of the alkaloid atropine.

Summarized Description.

White crystalline efflorescent powder or microscopical needles or crystals; very poisonous; soluble in about 0.4 part of water, in about 4 parts of alcohol and in about 3.1 parts of glycerin; less soluble in chloroform; sparingly soluble in ether, responds to the barium chloride reaction for sulphates. For details see U.S.P., p. 68.

For *other tests*, and for *impurities:* see atropine.

Remarks.—Atropine sulphate, being more soluble than the uncombined alkaloid, is generally used instead of the latter.

Dose.—5/10 milligramme (1/120 grain).

HOMATROPINÆ HYDROBROMIDUM—Homatropine Hydrobromide

(**Homatrop. Hydrobr.**—Homatropine Bromide)

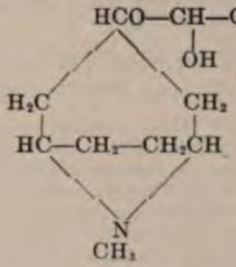
The hydrobromide [$C_{16}H_{21}NO_3.HBr=356.11$] of homatropine, an alkaloid obtained by the condensation of tropine and mandelic acid. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, odorless, crystalline powder or rhombic prisms; very poisonous; solutions dilate the pupil of the eye; soluble in about 6 parts of water, in about 32 parts of alcohol and in about 630 parts of chloroform. For details see U.S.P.

For *tests for identity* and for *impurities:* Foreign alkaloids (aqueous solution not precipitated by tannin; acidulated solution not precipitated by platinic chloride; chloroformic extract of the freed alkaloid, on evaporation, colored brick-red by mercuric chloride). Atropine, hyoscyamine, or hyoscine (does not respond to Vitali's reaction see U.S.P., p. 213.

Remarks.—Homatropine is an artificial alkaloid made by the condensation of tropine and mandelic acid. It is phenyl-glycocoll-tropin.



Its action is similar to atropine, but is less poisonous. As a mydriatic—a dilator of the pupil of the eye—it is preferable to atropine, because it works more rapidly.

Dose.—1/2 milligramme (1/120 grain).

Hyoscyamine.—Hyoscyamine, as the formula $C_{17}H_{23}NO_3$ shows, is isomeric with atropine, and when either atropine or hyoscyamine is treated with weak baryta water, both split into tropic acid and tropine. When it is said that hyoscyamine and atropine are isomeric, it must not be understood that the two are identical, for we have already learned, when considering tartaric acids (p. 615), that there may be many chemicals having similar formula, but different characteristics.

Amenomiya has shown that atropine (which is optically inactive) consists of the official hyoscyamine (which is lævogyre) and a dextrogyrate alkaloid isomeric with hyoscyamine.

Extraction.—Hyoscyamine is extracted either from the mother liquor left after atropine crystallization or from hyoscyamus seeds freed from fat by percolation with petroleum ether. The fat-free seeds are extracted with 85 per cent. alcohol acidulated with hydrochloric acid, the alcohol evaporated from percolate in vacuo, and the watery residue again treated with petroleum ether or chloroform to remove fat and color. The liquid is then made alkaline with potassium carbonate and shaken out with chloroform. The chloroformic solution is then evaporated at low temperature, and the crude alkaloid that remains is purified by crystallization from diluted sulphuric acid solution. From this crystalline sulphate the alkaloid can be obtained by making its aqueous solution alkaline, shaking out with chloroform, and evaporating the chloroformic solution.

The pharmacopœia provides in the gold chloride test the method of distinguishing the hyoscyamine from atropine. Hyoscyamine, like atropine, is not precipitated by platinic chloride test solution, as are most of the alkaloids. Free hyoscyamine is not official, but its hydrobromide and sulphate are.

HYOSCYAMINÆ HYDROBROMIDUM—Hyoscyamine Hydrobromide

(Hyoscyamin. Hydrobr.—Hyoscyamine Bromide)

The hydrobromide [$C_{17}H_{23}NO_3.HBr = 370.12$] of hyoscyamine, an **alkaloid** obtained from hyoscyamus and other plants of the *Solanaceæ*. **Preserve it in well-closed containers, protected from light.**

Summarized Description.

White prismatic deliquescent crystals; very poisonous; solutions dilate the pupil of the eye; soluble in about 2 parts of alcohol and in about 2.5 parts of chloroform; very soluble in water; slightly soluble in ether; aqueous solution is lævorotatory; melts at 152°C. For details see U.S.P.

Color Tests.—On shaking aqueous solution containing some chlorine water with chloroform, the latter turns brown. Also Vitali's reaction. See U.S.P., p. 224.

Impurities.—Atropine or scopolamine (behavior of gold double salt). Other alkaloids (solution not precipitated by platinic chloride). Carbonizable impurities (sulphuric acid solution not colored more than faint yellow.).

Extraction.—See under Hyoscyamine.

Remarks.—This salt has an effect similar to atropine.

Dose.—3/10 milligramme (1/200 grain).

Hyoscyaminæ Sulphas (U.S.P. VIII), or hyoscyamine sulphate ($(C_{17}H_{23}NO_3)_2H_2SO_4$, is used the same as the hydrobromide and in the same dose.

Hyoscine.—This alkaloid has the formula $C_{17}H_{21}NO_4$, and is isomeric with scopolamine (see below). Some time since there was much controversy relative to the composition of hyoscine, some authorities claiming it was isomeric with atropine and hyoscyamine. The present pharmacopœia takes the view that it is the same as scopolamine and therefore includes the formerly official *hyoscine hydrobromide* in the monograph on scopolamine hydrobromide.

Hyoscine is made from the mother liquor remaining after removal of hyoscyamine from the seed of hyoscyamus or stramonium, by treating the liquor with hydrobromic acid, and crystallizing the resultant hydrobromide.

The crude salt is purified by formation of the double chloride of the alkaloid and gold, and eventual separation of the gold by use of hydrogen sulphide.

SCOPOLAMINÆ HYDROBROMIDUM—Scopolamine Hydrobromide

(Scopolamin. Hydrobrom.—Hyoscine Hydrobromide—Scopolamine Bromide)

The hydrobromide [$C_{17}H_{21}NO_4HBr + 3H_2O = 438.15$] of lævorotatory scopolamine, also known as hyoscine, obtained from various plants of the *Solanaceæ*. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless transparent slightly efflorescent rhombic crystals, very poisonous; soluble in about 1.5 parts of water and in about 16 parts of alcohol; slightly soluble in chloroform; insoluble in ether; when dried it melts between 190° and 192°C.; lævorotatory. For details see U.S.P.

For *tests for identity* and for *impurities:* Foreign alkaloids (solution not made turbid by ammonia water; only slight turbidity on adding potassium hydroxide solution). Apoatropine (does not decolorize permanganate solution). Carbonizable impurities (sulphuric acid solution not more than faintly yellow). Morphine (orange, not red color, on adding nitric acid to the sulphuric acid solution) see U.S.P., p. 372.

Uses.—Similar to hyoscyamine.

Dose.—3/10 milligramme, (1/200 grain).

COCAINA—Cocaine

(Cocain.)

An alkaloid [$C_{17}H_{21}NO_4$ or $C_8H_{13}(C_6H_5CO)NO.COOCH_3 = 303.18$] obtained from *Erythroxylon Coca* Lamarck and its varieties (Fam. *Erthroxylaceæ*). Preserve it in well-closed containers protected from light.

Summarized Description.

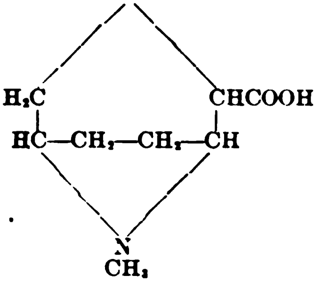
Large colorless four-sided or six-sided monoclinic prisms, or white crystalline powder; soluble in about 600 parts of water and in about 5 parts of alcohol; also soluble in chloroform, ether and olive oil; melts between 96° and 98°C. For details see U.S.P.

For *tests for identity* and for *impurities* see cocaine hydrochloride.

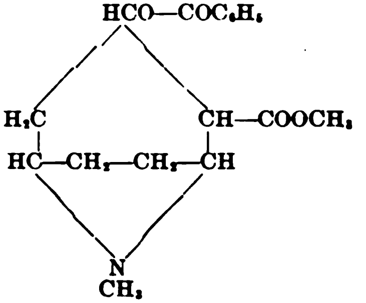
Extraction.—Coca leaves are extracted with 0.5 per cent. sulphuric acid, the percolate concentrated, made alkaline with sodium carbonate, and shaken out with kerosene. The kerosene solution is shaken with acidulated water, alkaloid precipitated from the aqueous liquid by addition of sodium carbonate, and the freed alkaloid obtained by evaporation of the ethereal solution is purified by again dissolving in acidulated water, precipitation with alkali, and recrystallization from alcohol or ether.

Remarks.—This important alkaloid, which was first isolated from coca-leaves by Niemann is now known to be benzoyl-methyl-ecgonine, the ecgonine being a carbonic acid derivative of tropine. A comparison of the formulas of the two substances, ecgonine and cocaine, is given below:

Ecgonine.



Cocaine.



Dose.—15 milligrammes (1/6 grain). Used in *Oleate of Cocaine* (p. 215).

COCAINÆ HYDROCHLORIDUM—Cocaine Hydrochloride

(Cocain. Hydrochl.—Cocaine Chloride—Cocainum hydrochloricum P.I.)

The hydrochloride [$C_{17}H_{21}NO_4.HCl = 339.65$] of the alkaloid cocaine.

Summarized Description.

Colorless, transparent monoclinic prisms, or flaky lustrous leaflets, or white crystalline powder; soluble in about 0.4 part of water in about 2.6 parts of alcohol and in about 18.5 parts of chloroform; also soluble in glycerin; insoluble in ether; lævorotatory; melts between 183° and 191°C. For details see U.S.P.

For *tests for identity* and for *impurities:* Cinnamyl-cocaine (acidulated solution does not readily decolorize permanganate). Isatropyl-cocaine (treated under proper conditions with ammonia water, the supernatant liquid is not milky). Readily carbonizable matter (sulphuric acid solution not more than slight yellow). See U.S.P., p. 117.

Remarks.—This soluble salt of cocaine is the one generally used whenever cocaine is indicated.

Sterilized cocaine solutions are now in some demand. These can be made by heating a 2 to 4 per cent. solution between 110° and 120°, provided the glass vessel employed does not contain free alkali.

While cocaine was isolated as far back as 1855, the use of the alkaloid dates from the last thirty years, a demand for the product not being started until local anesthetic action of cocaine had become known in 1884. When small quantities of cocaine are rubbed on the mucous membrane or injected beneath the skin, a benumbing of the nerves in that immediate neighborhood results, and so thorough is this insensibility that operations can be performed without pain where great agony would be produced were the parts not cocainized. On account of this valuable action of cocaine its use in all minor surgical operations spread widely, particularly in dentistry and operations on the nose and throat. From its original legitimate purpose cocaine has been prostituted into producing a sedative action in cases where wholly unnecessary. This is particularly true of catarrh powders, and it is through the use of such catarrh powders containing cocaine that the abuse of the drug increased throughout the country, until it became necessary to pass a rigid national law preventing its use except upon physician's prescriptions.

Dose.—15 milligrammes (¼ grain).

BETAEUCAINÆ HYDROCHLORIDIUM—Betaeucaine Hydrochloride

(Betaeucain. Hydrochl.—Eucaine Chloride—Eucaine)

A synthetic derivative of piperidine, containing, when dried to constant weight at 100°C., not less than 99 per cent. of 2, 6, 6-trimethyl-4-benzoyl-oxy-piperidine $C_{15}H_{21}NC$ HCl or $C_5H_7N(CH_3)_3(C_6H_5COO)HCl = 283.65$].

Summarized Description.

White crystalline powder; soluble in about 30 parts of water, in about 28 parts of alcohol and in about 9 parts of chloroform. For details see U.S.P.

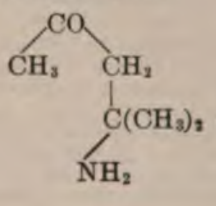
For *tests for identity*, for *impurities:* Readily carbonizable matter (sulphuric acid solution is colorless). Cocaine and alphaeucaine (solution is not precipitated by mercuric chloride) see U.S.P., p. 77.

For *assay* see Part V.

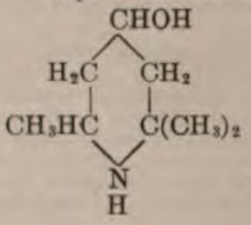
Remarks.—This new official is a synthetic alkaloid, the hydrochloride of trimethyl-benzoyl-hydroxypiperidine.

It is made by treating diacetonamine—(*a*) with paraldehyde, the product reduced by use of metallic sodium to vinyl-di-acetone-alkamine (*b*), and this treated with benzoyl chloride, whereupon the free base eucaine (*c*) results.

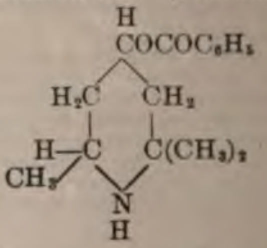
(*a*)
Diacetonamine.



(*b*)
Vinyl-di-acetone-alkamine.



(*c*)
β-eucaine.



It will be seen that eucaine has no chemical connection with cocaine, but, being used like it, is considered at this place. It is claimed that eucaine is an efficient local anesthetic, and that it does not produce a debasing habit, as does cocaine. Eucaine possesses the advantage over cocaine that it is stable and its solutions can be boiled, thus permitting sterilization. Cocaine when heated to the temperature of sterilization (110°C.) is apt to decompose.

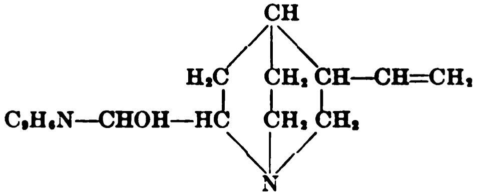
Dose.—Used only externally as local anesthetic.

Alpha-eucaine, the hydrochloride of benzoyl-methyl-tetra-methyl-oxypiperidine carboxylic-methyl-ester is used like beta-eucaine.

GROUP III.—QUINOLINE DERIVATIVES

Quinoline itself has already been discussed on p. 795, where the structural formula is fully explained, and here reference need only be made to the alkaloidal derivatives of this base.

Cinchonine ($C_9H_6N—C_9H_{12}OHNCH_3$) is one of the three official alkaloids obtained from the cinchona bark. Of the species of cinchona yielding more or less of this alkaloid, it is found most abundantly in Huanuco cinchona. The structure of cinchonine has been studied from the decomposition products, and is supposed to be—



the quinoline base being attached to a complex piperidine derivative.

CINCHONINÆ SULPHAS—Cinchonine Sulphate

(Cinchonin. Sulph.)

The sulphate [$(C_{19}H_{22}N_2O)_2.H_2SO_4+2H_2O=722.51$] of an alkaloid obtained from the bark of several species of cinchona. Preserve it in well-closed containers protected from light.

Summarized Description.

White lustrous, prismatic crystals; very bitter taste; soluble in about 60 parts of water, in about 10 parts of alcohol and in about 69 parts of chloroform; sparingly soluble in ether; aqueous solutions are dextrorotatory; solution in diluted sulphuric acid, slightly fluorescent. For details see U.S.P., p. 350.

For *tests for identity* and for *impurities:* Quinine or cinchonidine sulphate (completely soluble in 150 parts of chloroform). Readily carbonizable matter (sulphuric acid solution not more than faintly yellow) see U.S.P., p. 114.

Remarks.—Of the reactions for cinchonine, the only one calling for special attention is the interesting fact that, differing from quinine and cinchonine, it does not give a blue fluorescence in acid solutions. Cinchonine is used as an antipyretic—to reduce fevers—and as a remedy for malaria.

Dose.—150 milligrammes (2½ grains).

QUININA—Quinine

(Quin.)

An alkaloid [$C_{20}H_{24}O_2N_2+3H_2O=378.26$] obtained from the bark of various species of *Cinchona* (Fam. *Rubiaceæ*). Preserve it in well-closed containers, protected from light.

Summarized Description.

White, microcrystalline, efflorescent powder; slowly developing, but intense and persistent bitter taste; soluble in about 1550 parts of water and in about 0.6 part of alcohol; also soluble in chloroform and ether; sparingly soluble in ammonia water; alcohol solution is lævorotatory; solution in diluted sulphuric acid is intensely fluorescent. For details see U.S.P., p. 350.

For *tests for identity* and for *impurities:* Other organic matter (sulphuric acid solution is not more than light yellow). Morphine (the above solution not colored red by nitric acid). Ammonium salts (no ammoniacal odor on heating with potassium hydroxide solution). Other cinchona alkaloids (see quinine sulphate) see U.S.P., p. 350.

Extraction.—There are so many old methods of extraction of the cinchona alkaloids found in the literature and so little modern information on the subject, that the following process, given by Field, is offered merely as a type. The bark is mixed with about one-fifth of its weight of slaked lime and is then extracted with a mixture of 75 per cent. of kerosene and 25 per cent. of fusel oil. The percolate is then shaken out with 6 per cent. sulphuric acid; the acid layer is separated, neutralized with saturated solution of sodium hydroxide and decolorized with animal charcoal, after which it is filtered into lead-lined crystallizing boxes. After twelve hours the separated crystals are removed from the mother liquid by use of a filter press. This first crop of crystals (chiefly quinine sulphate with some cinchonidine sulphate) are recrystallized until a pure quinine salt is obtained. To the mother liquor mentioned above, sodium carbonate solution is added and the separating alkaloids are dissolved in diluted acid and are recrystallized. The purified alkaloidal mixture is then treated with enough tartaric acid to make a normal tartrate and as a result the tartrates of quinine and cinchonidine are precipitated. To the "tartrated" mother liquor, containing quinidine and cinchonine, enough tartaric acid is added to make acid tartrates, which precipitate from boiling solutions. This crystalline precipitate is treated with concentrated sulphuric acid, which dissolves the quinidine; the residue is then treated with the kerosene-fusel oil mixture, which dissolves the remaining quinine and cinchonidine; after which the still undissolved cinchonine is crystallized from diluted sulphuric acid. In other methods, gasoline is used as the extracting solvent; the quinidine is removed by use of ammonia and the cinchonidine is precipitated by addition of a solution of Rochelle salt.

Remarks.—This important alkaloid was isolated by Pelletier and Caventou, two apothecaries of Paris in, 1820. Investigations show that quinine is a methoxycinchonine, $C_9H_5(OCH_3)N—CHOH—C_9H_{14}N$.

The synthesis of quinine has not yet been accomplished.

Of the reactions given in the pharmacopœia quite characteristic is the blue fluorescence produced when quinine is dissolved in acid. A very beautiful test is the thalleioquin test; which is given in the Pharmacopœia, consisting of the treatment of a faintly acid quinine solution with bromine water, and the excess of ammonia, when the liquid assumes a vivid green tint.

Another characteristic test is the one based on the production of *herapathite*, the green crystals of quinine iodosulphate formed when the alkaloid is mixed with acetic acid, alcohol and sulphuric acid and is then treated with an alcoholic solution of iodine.

Besides, in the free form, quinine is recognized by the pharmacopœia as bisulphate, hydrobromide, hydrochloride, di-hydrochloride, salicylate, sulphate and the hydrochloride with urea. Of these salts of quinine the most popular is the sulphate. Quinine sulphate is only sparingly soluble in water, but when an aqueous mixture of the sulphate is treated with sulphuric acid, the salt rapidly goes into solution. This is due to the formation of the bisulphate of quinine, one part of which dissolves in 9 parts of water, whereas one part of quinine sulphate requires 725 parts of water for solution. There is a question, however, as to the wisdom of dispensing quinine solutions, as by dissolving the salt its bitter taste is made still more pronounced. It is, in fact, preferable to administer the same in a mixture with a "shake well" label, and in such a mixture the taste of the quinine can be effectively masked by the use of preparations of licorice, such as ammoniated glycyrrhizin or an aqueous fluidextract of licorice (such as is now official). Compound syrup of sarsaparilla has also been found useful to mask the taste of quinine, but it is not so effective as are licorice preparations.

There has been a great demand for the preparations of quinine devoid of the disagreeable taste. For adults the administration of quinine capsules covers the need, but in the case of children who cannot swallow capsules some liquid method of administration is exceedingly desirable. The nearest approach to a palatable quinine liquid is a licorice combination of quinine, as cited above. There have been put on the market proprietary liquid preparations purporting to contain quinine, but investigation shows that such preparations contain practically no quinine, the less bitter and also less effective quinidine being used instead. Such a preparation is the syrup of quinidine of the National Formulary (p. 203). In fact, practically the only way satisfactorily to administer quinine internally to children is as quinine tannate in the form of chocolate lozenges, and this method is highly satisfactory. The physiologic effect of quinine can also be secured by preparing an ointment of quinine (the alkaloid or the sulphate) with benzoinated lard or petrolatum and lanoline, this ointment being applied by rubbing under the armpits. Oleate of quinine, N.F. (p. 215), can be used for the same purpose.

Physicians at times prescribed quinine with licorice, then direct addition of diluted sulphuric acid to dissolve the quinine. In such combination (see p. 948) the sulphuric acid will immediately precipitate the glycyrrhizin from the licorice preparation, producing an unsightly mixture, and at the same time one which is nauseatingly bitter.

The writer knew of one physician who prescribed the sulphate under the name of "Sulfat de pelletiere," the object of this peculiar synonym being the same as actuated the physician who prescribed the same substance under the name of "sulphatis Americanis Australis" (South American sulphate). In each case the patient had a notion that quinine was repugnant to her system, and in order to permit the administering of same without arousing her suspicions, these peculiar synonyms were employed. It must be said, however, that the first synonym is scarcely short of dangerous, inasmuch as the alkaloid pelletierine, obtained from pomegranate bark (see p. 827), is an article of commerce, and now official as the tannate, and "sulfat de pelletiere" should be left to designate the sulphate of this alkaloid.

In view of the full description of quinine and its salts just given, it is now necessary merely to insert the pharmacopœia data relative to the official salts of quinine.

Dose.—As tonic, 100 milligrammes (1½ grains); as anti-malarial at least 1 gramme (15 grains) daily.

QUININÆ BISULPHAS—Quinine Bisulphate

(Quin. Bisulph.)

The acid sulphate [$C_{20}H_{24}O_2N_2.H_2SO_4+7H_2O$ = 548.41] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, transparent, efflorescent orthorhombic crystals or small needles; very bitter taste; turns yellow on exposure to light; soluble in about 9 parts of water, in about 18 parts of alcohol and in about 18 parts of glycerin; sparingly soluble in chloroform and ether. For details see U.S.P.

For *tests for identity* and for *impurities*, see quinine sulphate.

Dose.—See Quinine.

QUININÆ HYDROBROMIDUM—Quinine Hydrobromide

(**Quin. Hydrobr.**—Quinine Bromide)

The hydrobromide [$C_{20}H_{24}O_2N_2.HBr+H_2O=423.16$] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, light, efflorescent, silky needles; very bitter taste; soluble in about 40 parts of water, in about 0.7 part of alcohol, in about 8 parts of glycerin and in about 0.9 part of chloroform; less soluble in ether; solution in diluted sulphuric acid has a vivid blue fluorescence. For details see U.S.P.

For *tests for identity* see U.S.P., p. 352. For *impurities:* Carbonizable matter and morphine, see Quinine. Barium and sulphate, see Part V of this book. Other cinchona alkaloids (modified Kerner's test), see p. 813.

Dose.—See Quinine.

QUININÆ ET UREÆ HYDROCHLORIDUM—Quinine and Urea Hydrochloride

(**Quin. et Urea. Hydrochl.**—Quinine and Urea Chloride)

A compound of the hydrochlorides of quinine and urea [$C_{20}H_{24}O_2N_2.HCl.CO(NH_2)_2.HCl+5H_2O = 547.28$] which contains not less than 58 per cent. of anhydrous quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, translucent prisms or white granular powder; very bitter taste; soluble in about 0.9 part of water and in about 2 parts of alcohol. For details see U.S.P., p. 351.

For *tests for identity* and for *impurities:* (carbonizable matter and ammonium salts) see Quinine.

Outline of Assay.—Make aqueous solution alkaline with potassium hydroxide and then shake out with three portions of ether. Ethereal extract on evaporation is dried and weighed. Yield at least 58 per cent. of weight of original sample. For details see U.S.P., p. 352.

Remarks.—This new official chemical, which is sometimes called *chininum bihydrochloricum carbamidum,* is made by making a solution of quinine dihydrochloride and then adding to this the molecular quantity of urea. It has lately attained great popularity not merely as an ideal quinine salt for hypodermic administration, but as a local anesthetic.

Dose.—Hypodermic (one dose daily) 1 gramme (15 grains).

QUININÆ DIHYDROCHLORIDUM—Quinine Dihydrochloride

(**Quin. Dihydrochl.**)

The dihydrochloride [$C_{20}H_{24}O_2N_2.2HCl = 397.15$] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White powder; very bitter taste; soluble in about 0.6 part of water and in about 10 parts of alcohol; slightly soluble in chloroform and in ether. For details see U.S.P., p. 351.

For *tests for identity* see U.S.P. For *impurities:* Carbonizable matter and morphine, see Quinine Sulphate. Sulphate and barium, see Part V of this book. Other cinchona alkaloids (modified Kerner's test), see p. 813.

Remarks.—The new official salt of quinine has the same advantage over the hydrochloride that the bisulphate has over the sulphate; superior solubility. Thus while the hydrochloride requires 16 parts of water to effect solution, the dihydrochloride is soluble in 0.6 part of water. Like all quinine salts, it is a tonic.

Dose.—See Quinine.

QUININÆ HYDROCHLORIDUM—Quinine Hydrochloride

(Quin. Hydrochl.—Quinine Chloride)

The hydrochloride [$C_{20}H_{24}O_2N_2.HCl+2H_2O=396.71$] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, silky, glistening, efflorescent needles; very bitter taste; soluble in about 18 parts of water, in about 0.6 part of alcohol, in about 8 parts of glycerin and in about 10 parts of chloroform; less soluble in ether; aqueous solution not fluorescent until acidulated with sulphuric acid. For details see U.S.P.

For *tests for identity* see U.S.P., p. 353. For *impurities:* Carbonizable matter and morphine, see Quinine. Other cinchona alkaloids (modified Kerner's test) see Quinine sulphate. Sulphate and barium, see Part V of this book.

Dose.—See Quinine.

QUININÆ SALICYLAS—Quinine Salicylate

(Quin. Salicyl.)

The salicylate $C_{20}H_{24}O_2N_2.C_7H_6O_3+H_2O=480.28$] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, needles, turning pinkish on ageing; bitter taste; soluble in about 77 parts of water; in about 11 parts of alcohol and in about 16 parts of glycerin; also soluble in chloroform; sparingly soluble in ether. For details see U.S.P., p. 354.

For *tests for identity* see U.S.P. For *impurities:* Sulphate and chloride, see Part V of this book. Other cinchona alkaloids (modified Kerner's test) see Quinine sulphate.

Dose.—See Quinine.

QUININÆ SULPHAS—Quinine Sulphate

(Quin. Sulph.)

The sulphate [$(C_{20}H_{24}O_2N_2)_2.H_2SO_4+7H_2O = 872.62$] of the alkaloid quinine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, silky, light, flexible glistening, efflorescent crystals, making an easily compressible mass, or hard prismatic monoclinic needles; persistent bitter taste; darkens on exposure to light; soluble in about 725 parts of water, in about 86 parts of alcohol and in about 36 parts of glycerin; slightly soluble in chloroform and ether; easily soluble in a mixture of 7 volumes of chloroform and 4 volumes of dehydrated alcohol; solution in diluted sulphuric acid shows vivid blue fluorescence. For details see U.S.P., p. 355.

For *tests for identity* (including thalleioquin reaction) see U.S.P. For *impurities:* Ammonium salts (completely soluble in a mixture of 2 volumes of chloroform and 1 volume of dehydrated alcohol). Other cinchona alkaloids (carefully prepared aqueous solution remains clear when mixed with a definite amount of ammonia water at 15°C.) see U.S.P., p. 355. Carbonizable matter and morphine, see Quinine.

Remarks.—The official test for distinguishing quinine from other cinchona alkaloids is a modification of *Kerner's test*, which required that when an evaporated mixture of quinine and ammonium sulphate is treated with water and filtered, the filtrate should yield a clear liquid with a specific quantity of ammonia water. Quinine and all its alkaloids are valuable antipyretics and antiperiodics, that is, they reduce fever and relieve malaria. The different acids combined with the alkaloid in the several salts somewhat modify the action according to the properties of the acid.

Dose.—See Quinine.

Quinidine.—*Extraction.*—See Quinine (p. 810).

Remarks.—Quinidine, $C_{20}H_{24}N_2O_2$, is isomeric with quinine, and, like it, is supposed to be methoxycinchonine.

It is of minor importance in medicine, having been official in the pharmacopœia of 1890 in the form of sulphate.

The salts of quinidine, like those of quinine, show a fluorescence in acid solution, and quinidine also responds to the thalleioquin test.

QUININÆ TANNAS—Quinine Tannate

(Quin. Tan.)

A compound of the alkaloid quinine with tannic acid, of somewhat varying composition and containing not less than 30 per cent. nor more than 35 per cent. of anhydrous quinine ($C_{20}H_{24}O_2N_2$). Preserve it in well-closed containers, protected from light.

Summarized Description.

Pale yellow or yellowish-white amorphous powder; not more than slightly bitter and astringent; slightly soluble in water, chloroform or ether; more soluble in alcohol. For details see U.S.P.

For *tests for identity* and for *impurities:* Uncombined quinine (extracted with three portions of ether; the ethereal solution, on evaporation yields not more than 0.5 per cent. of residue). Heavy metals, chlorides, sulphates (usual tests) see U.S.P., p. 356 and also Part V of this book.

Outline of Assay.—Mix the tannate with water and ammonia water and then shake out with several portions of ether. The mixed ethereal extracts on evaporation yield a residue, which when dried, weighs from 30 to 35 per cent. of the original sample taken. For details see U.S.P.

Remarks.—As mentioned on p. 811 this new official salt of quinine has the advantage of being almost devoid of bitterness.

Dose.—200 milligrammes (3 grains).

Cinchonidine.—*Extraction.*—See Quinine (p. 810).

Remarks.—Cinchonidine is isomeric with cinchonine, and is supposed to have the same graphic formula (p. 810). It is only sparingly soluble in ammonia water, and this explains the principle of Kerner's test for quinine described on p. 813. The sodium and potassium tartrate test given below in the monograph on cinchonidine sulphate is based upon the fact that Rochelle salt prevents the precipitation of cinchonidine by ammonia water; whereas cinchonine and quinidine are precipitated when so treated.

A striking test for cinchonidine is the color produced by the oxidation of the alkaloid by means of a crystal of potassium dichromate and sulphuric acid, when a brilliant, grass-green color results.

CINCHONIDINÆ SULPHAS—Cinchonidine Sulphate

(Cinchonid. Sulph.)

The sulphate $[(C_{19}H_{22}N_2O)_2.H_2SO_4+3H_2O = 740.53]$ of an alkaloid obtained from the bark of several species of cinchona. Preserve it in well-closed containers protected from light.

Summarized Description.

White, glistening, silky needles or prisms; very bitter taste; soluble in about 65 parts of water, in about 72 parts of alcohol and in about 900 parts of chloroform; almost insoluble in ether; aqueous solution is lævorotatory; when dried, melts at 200°C., with partial decomposition; solution in diluted sulphuric acid only faintly fluorescent. For details see U.S.P.

For *tests for identity* and for *impurities:* Cinchonine and quinidine sulphate (when the salt is mixed with water and with potassium and sodium tartrate and then filtered; the filtrate is not made more than faintly turbid by a trace of ammonia water) see U.S.P., p. 113. Carbonizable matter, see Quinine.

Remarks.—This alkaloidal salt enjoyed a large sale prior to 1880, when the high price of quinine sulphate (which then sold at $5 an ounce) made that important alkaloid a luxury. It is used like quinine, but is not so effective.

Dose.—150 milligrammes (2½ grains).

STRYCHNINA—Strychnine

(Strych.)

An alkaloid [$C_{21}H_{22}O_2N_2 = 334.20$] obtained from nux vomica, and also obtainable from other seeds of the *Loganiaceæ*. Preserve it in well-closed containers.

Summarized Description.

Colorless, transparent, prismatic crystals or white crystalline powder; bitter and very poisonous; soluble in about 6400 parts of water in about 110 parts of alcohol and in about 7.5 parts of chloroform; also soluble in benzene; sparingly soluble in ether; aqueous solution is lævorotatory. For details see U.S.P., p. 416.

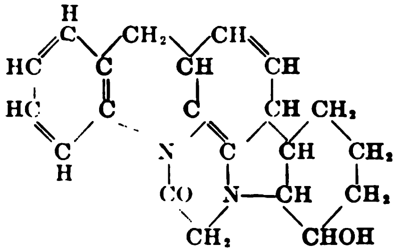
Color Tests.—Violet blue, then purple, then cherry red with sulphuric acid—ammonium vanadate reagent. Blue, then violet, then purplish red, then cherry red and finally orange yellow, with sulphuric acid and potassium dichromate.

Impurities.—Readily carbonizable matter, see quinine. Bromine (yellow, not red, with nitric acid). For details, see U.S.P.

Extraction.—Nux vomica is extracted with a diluted alcohol containing a trace of sulphuric acid. To the tincture thus obtained is added slaked lime enough to neutralise the acid after which the alcoholic solution of the free alkaloid is filtered from the lime precipitate and the alcohol is distilled. The residue after distillation of the alcohol is dissolved in diluted acid and to the filtrate enough ammonia is added to precipitate the strychnine and the brucine. The latter is then dissolved from the mixture by the use of cold diluted alcohol. Then the residue treated with boiling alcohol, which dissolves the strychnine, and this is decolorized by treatment with animal charcoal. The alkaloid is eventually precipitated from the alcoholic solution by treatment with alkali.

Remarks.—This alkaloid was discovered by Pelletier and Caventou in 1818. It is the active principle of nux vomica and Ignatia bean, from which it is extracted as explained above.

According to Perkin and Robinson, the graphic formula of strychnine is presumably



The synthesis of strychnine has not yet been accomplished.

Interesting among the reactions of strychnine is its behavior under different oxidizing agents. Thus, when strychnine is first dissolved in concentrated sulphuric acid (which it does without any change in color), and when a small crystal of potassium dichromate is added, a violet color changing to tints of red, then orange, and yellow results. This test is said to detect one part of strychnine in 500,000. It is, however, open to fallacy, Professor J. U. Lloyd having shown that a mixture of morphine and hydrastine will give a similar color reaction. Professor Lloyd makes the confusion of such a combination for strychnine a dramatic feature of one of his romances.

A very prominent characteristic of strychnine is its intensely bitter taste, the bitterness being shown in a dilution of 1 to 700,000, which can be stated more strikingly by saying that this dilution represents about a grain of strychnine to twelve gallons of water.

Strychnine is a powerful nervous stimulant, and is usually dispensed as a sulphate.

Dose.—1½ milligrammes (1/40 grain).

It is recognized by the pharmacopœia in the form of the free alkaloid, and also as the nitrate and the sulphate.

STRYCHNINÆ NITRAS—Strychnine Nitrate

(Strych. Nit.)

The nitrate [$C_{21}H_{22}O_2N_2.HNO_3 = 397.21$] of the alkaloid strychnine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless, glistening needles or white, crystalline powder; bitter, very poisonous; soluble in about 42 parts of water, in about 120 parts of alcohol and in about 60 parts of glycerin; less soluble in chloroform; insoluble in ether; aqueous solution is lævorotatory. For details see U.S.P., p. 416.

For *tests for identity* and for *impurities* see Strychnine.

Doses.—1½ milligrammes (1/40 grain).

STRYCHNINÆ SULPHAS—Strychnine Sulphate

(Strych. Sulph.)

The sulphate [$(C_{21}H_{22}O_2N_2)_2 \cdot H_2SO_4 + 5H_2O = 856.56$] of the alkaloid strychnine. Preserve it in well-closed containers.

Summarized Description.

Colorless or white, efflorescent, prismatic crystals or white, crystalline powder; soluble in about 32 parts of water and in about 65 parts of alcohol; also soluble in glycerin, less so in chloroform; insoluble in ether.

For *tests for identity* and for *impurities* see Strychnine.

Remarks.—Both the sulphate and the nitrate are used like the alkaloid, strychnine, and in the same dose.

Dose.—1½ milligrammes (1/40 grain).

Brucine is an unofficial alkaloid, associated with strychnine in nux vomica and igdatia. It is of little importance in pharmacy and medicine, except that some commercial strychnine has not been fully purified from brucine. This is detected by the fact that brucine when treated with concentrated nitric acid gives a brilliant red tint, while strychnine will dissolve practically colorless.

VERATRINA—Veratrine

(Veratrin.—Veratria.)

A mixture of alkaloids obtained from the seed of *Asagræa officinalis* (Chamisso and Schlechtendal) Lindley (Fam. *Liliaceæ*). Preserve it in well-closed containers, protected from light.

Summarized Description.

White or grayish-white hygroscopic, amorphous powder; odorless, but extremely irritating to the nasal mucous membrane; very poisonous; soluble in about 1750 parts of water, in about 2.2 parts of alcohol, in about 1 part of chloroform and in about 3 parts of ether; insoluble in petroleum benzin. For details see U.S.P., p. 486.

Color Tests.—Orange red, with greenish fluorescence, then deep red with sulphuric acid. Green, then blue, then colorless, with sugar and sulphuric acid.

Impurities.—Foreign alkaloids (not precipitated by platinic chloride) see U.S.P.

Extraction.—Powdered cevadilla seeds are extracted with 90 per cent. alcohol, the percolate concentrated and poured into a large quantity of water, thus precipitating resin, fat, etc. The aqueous liquid is then made alkaline with ammonia, and the precipitated veratrine purified by washing with water, dissolving in diluted hydrochloric acid, and precipitating with ammonia.

Remarks.—Veratrine is a mixture of alkaloids obtained from cevadilla seeds. The word veratrine is unfortunate, inasmuch as it would suggest that the alkaloid is obtained from the official veratrum. This is not the case, the alkaloid having originally been discovered in cevadilla seeds in 1818, by Meissner, who called the alkaloid sabadilline, suggesting, however, that if the same alkaloid was found in other species of veratrum, it might be well to call it veratrine. The same year, however, Pelletier and Caventou isolated veratrine from white veratrum, and from this fact the alkaloid obtained its name.

The chemistry of this alkaloid has been comparatively little studied. As above mentioned, it is now considered a mixture of alkaloids. It is a quinoline derivative, as shown by its decomposition products.

Its chief reactions, as cited above, are the colors produced with concentrated sulphuric acid, the tint ranging from yellow to cherry red, according to conditions of mixing.

It will be noted in the alkaloidal reactions of the new pharmacopœia that selenous acid plus sulphuric acid is given a place as an alkaloidal color reagent—in the case of veratrine a green-brown color is produced.

Veratrine is used internally very seldom, and then as a sedative. Its chief use is externally as a destroyer of vermin and in some forms of skin trouble, in which case it is usually dispensed as the official *oleate of veratrine* or as the ointment.

Dose.—No dose is given for veratrine in the present pharmacopœia. The last pharmacopœia put the dose at 2 milligrammes.

GROUP IV.—THE ISOQUINOLINE DERIVATIVES

Isoquinoline is a substance having the same empiric formula as quinoline, the only difference between the two being in the location of the nitrogen atom. (See formula of quinoline on page 796.)

HYDRASTINA—Hydrastine

An alkaloid [$C_{21}H_{21}NO_6 = 383.18$] obtained from hydrastis or prepared synthetically. Preserve it in well-closed containers, protected from light.

Summarized Description.

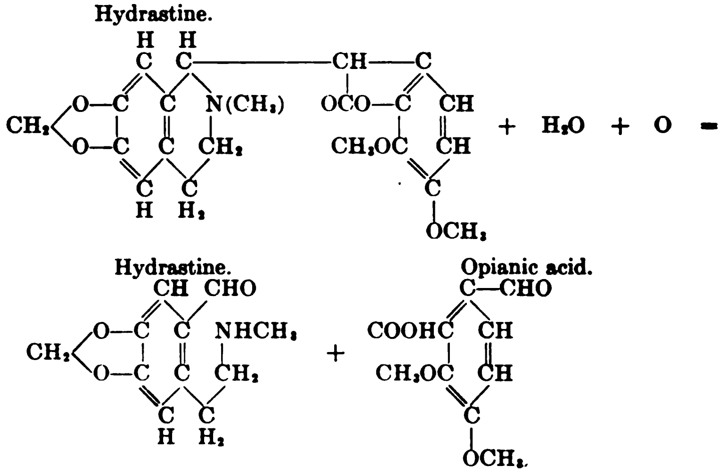
White to creamy-white glistening prisms or white micro-crystalline powder; almost insoluble in water; soluble in about 135 parts of alcohol and in about 2 parts of chloroform; also soluble in ether and in benzene; melts at 131°C. For details see U.S.P., p. 222.

Color Tests.—Yellow, then (on heating) purple, with sulphuric acid. Green, then olive green, then brown, with sulphuric acid—molybdic acid reagent. Reddish yellow, with nitric acid. Light green, then brown, with sulphuric acid—selenous acid reagent. For details see U.S.P.

Impurities.—Hydrastinine (solution in diluted sulphuric acid not fluorescent). Berberine (solution in diluted hydrochloric acid not reddened by chlorine water). For details see U.S.P.

Extraction.—A decoction of hydrastis is made with water containing acetic acid. This is evaporated to a syrup and mixed with three volumes of 20 per cent. sulphuric acid. This causes the separation of the crystals of bisulphate of berberine (yellow hydrastine). The mother liquor is made alkaline with ammonia, and the crude precipitated hydrastine is purified by recrystallization with alcohol or acetic acid.

Remarks.—Hydrastine, on treatment with oxidizing agents (diluted nitric acid), splits into hydrastinine and opianic acid:



Hydrastine occurs in handsome white crystals, soluble in 135 parts of alcohol and insoluble in water. It is largely used as an astringent, and especially in gonorrheal washes. Unfortunately, two articles are known in commerce as hydrastine, the white crystals above described, which are quite expensive, and the so-called *yellow hydrastine*, which is nothing less than berberine.

Dose.—10 milligrammes (1/6 grain).

HYDRASTINÆ HYDROCHLORIDUM—Hydrastine Hydrochloride

(Hydrastin. Hydrochl.—Hydrastine Chloride)

The hydrochloride [$C_{21}H_{21}NO_6.HCl = 419.65$] of the alkaloid hydrastine. Preserve it in well-closed containers, protected from light.

Summarized Description.

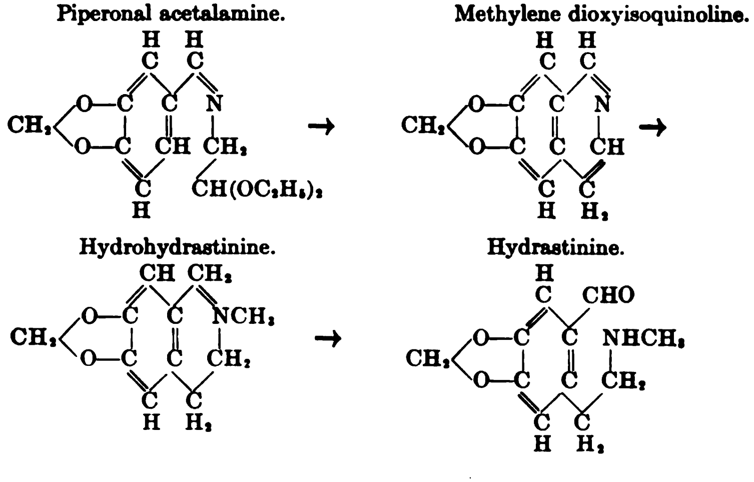
White to creamy-white hygroscopic powder; very soluble in water and in alcohol; less soluble in chloroform and in ether; gives the silver nitrate test for chlorides. For *tests for identity* and for *impurities* see hydrastine.

Remarks.—This salt of hydrastine has been made official in order to furnish a water soluble compound of the alkaloid.

Dose.—10 milligrammes (1/6 grain).

Berberine is an unofficial alkaloid obtained from hydrastis and also from the root of *Berberis vulgaris;* hence its name. To all these drugs it transmits its characteristic yellow color. Its structural formula is similar to hydrastine, although even more complex.

Hydrastinine.—This is an artificial alkaloid obtained from hydrastine by treatment with appropriate oxidizing agents. The synthesis of hydrastinine from piperonal acetalamine has been accomplished, the successive stages of this synthesis being graphically shown below:



HYDRASTININÆ HYDROCHLORIDUM—Hydrastinine Hydrochloride

(Hydrastinin. Hydrochl.—Hydrastinine Chloride)

The hydrochloride [$C_{11}H_{11}NO_2.HCl = 225.57$] of hydrastinine, an alkaloid obtained by the oxidation of hydrastine. Preserve it in well-closed containers, protected from light.

Summary of Description.

Light yellowish needles or yellowish-white crystalline powder; very soluble in water and alcohol; less soluble in chloroform and in ether; melts at 210°C. with partial decomposition; aqueous solutions show bluish fluorescence. For details see U.S.P., p. 223.

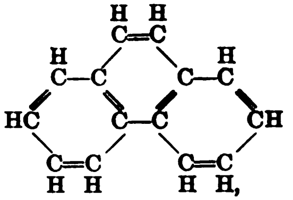
For *tests for identity and impurities:* Hydrastine (precipitate produced by bromine water makes an almost colorless solution with ammonia water). Foreign alkaloids (aqueous solution not made turbid by adding a few drops of ammonia water; solution treated with sodium hydroxide solution 1 in 7, gives almost colorless supernatant liquid), see U.S.P.

Remarks.—It is worth noting that an aqueous solution of this salt gives a blue fluorescence, somewhat similar to that exhibited by quinine. It is used as a uterine astringent.

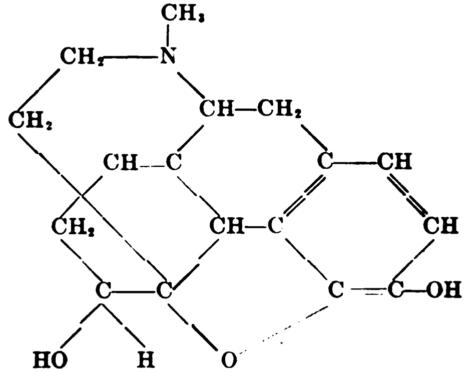
Dose.—30 milligrammes (½ grain).

GROUP V.—PHENANTHRENE DERIVATIVES

The difficulty of making a clear-cut definition for alkaloids is shown in the case of morphine and its allied opium alkaloids. The definition for alkaloids given on p. 797, states that they are derivatives of pyridine, quinoline, or allied bodies, and yet latest investigations seem to show that morphine, one of the most prominent alkaloids, is not a derivative of isoquinoline as long supposed, but is derived from phenanthrene, an isomere of anthracene, and, therefore, containing no nitrogen. The graphic formula of phenanthrene is—



and the graphic formula of morphine is supposed to be



The synthesis of morphine has not yet been accomplished.

MORPHINA—Morphine

An alkaloid [$C_{17}H_{19}O_3N+H_2O=303.18$] obtained from opium. Preserve it in well-closed containers, protected from light.

Summarized Description.

Colorless shining rhombic prisms or, fine needles or crystalline powder; soluble in about 3340 parts of water and in about 168 parts of alcohol and in 100 parts of lime water; also soluble in chloroform and ether; insoluble in benzene. For details see U.S.P., p. 276.

Color Tests.—Not more than reddish yellow with sulphuric acid. Orange red to yellow, with nitric acid. Blue, then green, then brown, with sulphuric acid—selenous acid reagent. Purple, then blue, with sulphuric acid—molybdic acid reagent. Deep purple, with sulphuric acid and formaldehyde. Deep blue, with potassium ferricyanide and ferric chloride. For details, see U.S.P.

Impurities.—Codeine (the ferricyanide test just given) meconic acid (solution in diluted hydrochloric acid not reddened by ferric chloride solution. Ammonium salts (no ammoniacal odor on heating with potassium hydroxide solution). Foreign alkaloids (a modified volumetric test). For details, see U.S.P.

Extraction.—An aqueous infusion of opium is made alkaline and the precipitated alkaloid after filtration and washing, is dissolved in a diluted sulphuric acid. This acid solution is decolorized, by filtration through animal charcoal, is then concentrated and is crystallized in a leaden tank. If the solution is of the proper density, when it is stirred while cooling, the morphine sulphate crystallizes suddenly to a solid mass This accomplished, the mother liquor is allowed to drain from the tank, the crystalline mass is cut into bricks, which are placed upon absorbent surfaces and are then allowed to dry. During this drying, the coloring matter comes to the surface of the brick forming a brown or black scurf. This is cut off with a sharp knife, leaving the rest of the brick practically pure morphine sulphate. From this, of course, the other salts of morphine and the alkaloid itself can be prepared.

Remarks.—Morphine is, with the possible exception of quinine, the most important of the alkaloids. It is also interesting as being the first alkaloid to be isolated, its separation from opium being accomplished by Sertürner, an apothecary of Eimbeck, in 1806.

Important points in the tests just given are: The color produced by the alkaloid in combination with sulphuric acid and molybdic acid and the blue-green-brown color-play produced by action of morphine on sulphuric acid and selenous acid. These tests distinguish morphine from the other opium alkaloids.

Morphine, when sprinkled upon concentrated nitric acid, gives a red color similar to brucine. The reaction, however, differs from the brucine reaction by being less permanent, and is of value, distinguishing morphine from quinine.

Morphine is used like opium as a hypnotic and sedative.

Dose.—8 milligrammes (1/8 grain).

Morphine is official in the form of the free alkaloid, also as acetate, hydrochloride, and the sulphate.

MORPHINÆ HYDROCHLORIDUM—Morphine Hydrochloride

(Morph. Hydrochl.—Morphine Chloride)

The hydrochloride [$C_{16}H_{19}O_3N.HCl+3H_2O=375.68$] of the alkaloid morphine. Preserve it in well-closed containers protected from light.

Summarized Description.

White silky glistening needles, or cubical masses, or white crystalline powder; soluble in about 17.5 parts of water and in about 42 parts of alcohol; also soluble in glycerin; insoluble in ether and in chloroform; gives the silver nitrate test for chlorides. For details see U.S.P., p. 276.

For *tests for identity* and for *impurities*, see morphine.

Other Impurity.—Apomorphine (aqueous solution treated with potassium carbonate and then shaken with chloroform does not give a green lower layer.) See U.S.P., p. 277.

Dose.—8 milligrammes (1/8 grain).

MORPHINÆ SULPHAS—Morphine Sulphate

(Morph. Sulph.)

The sulphate [$(C_{17}H_{19}O_3N)_2.H_2SO_4+5H_2O=758.49$] of the alkaloid morphine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, feathery, acicular, silky crystals or cubical masses; soluble in about 15.5 parts of water and in about 457 parts of alcohol; insoluble in chloroform or ether; gives barium chloride test for sulphates. For details, see U.S.P., p. 277.

For *tests for identity* and for *impurities*, see morphine.

Remarks.—These two morphine salts are used like the alkaloid. Of them, the sulphate is the most largely used.

Magendie's solution is an aqueous solution of morphine sulphate, 16 grains to the fluidounce. *Syrup of Morphine*, 1 grain morphine to the fluidounce, is used in the south, where a mixture of equal quantities of the syrups of squill, tolu, morphine, and ipecac is prescribed as "*four syrups*," or "*syrupus quatuor.*"

Dose.—8 milligrammes (1/8 grain).

DIACETYLMORPHINA—Diacetylmorphine

(Diacetylmorph.)

An alkaloid [$C_{21}H_{23}NO_5$ or $C_{17}H_{17}(O.C_2H_3O)_2NO = 369.19$] prepared from morphine by acetylization. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, crystalline, inodorous powder; soluble in about 1700 parts of water, in about 25 parts of alcohol and in about 2 parts of chloroform; also soluble in ether; melts between 171.5° and 173.5°C.

Color Test.—Yellow, then greenish blue with nitric acid. For details, see U.S.P.

Impurities.—Other alkaloids (soluble in 5 per cent. potassium hydroxide solution). Ammonium salts (no ammoniacal odor on heating with potassium hydroxide solution). Readily carbonizable matter (makes colorless sulphuric acid solution). Morphine (no blue color with potassium ferricyanide—ferric chloride reagent). Foreign alkaloids (modified volumetric test). For details see U.S.P., p. 130.

Remarks.—This new official substance, largely used under the name *heroin,* is an acetic ester of morphine prepared by replacing two hydroxyl, groups of that alkaloid by acetyl groups. This acetylization is accomplished by heating morphine with acetyl chloride, washing the product with diluted alkali solution and then with water and finally crystallizing from alcohol. It is used as a sedative and since it has been misused, it is one of the prohibited drugs mentioned in antinarcotic laws.

Dose.—3 milligrammes (1/20 grain).

DIACETYLMORPHINÆ HYDROCHLORIDUM—Diacetylmorphine Hydrochloride

(Diacetylmorph. Hydrochl.—Diacetylmorphine Chloride)

The hydrochloride [$C_{21}H_{23}NO_5.HCl+H_2O$ or $C_{17}H_{17}(O.C_2H_3O)_2NO.HCl+H_2O$ = 423.68] of the alkaloid diacetylmorphine. Preserve it in well-closed containers, protected from light.

Summarized Description.

White, crystalline powder; soluble in water and alcohol; insoluble in chloroform or ether; melts at 230°C.; gives silver nitrate test for chlorides. For details see U.S.P., p. 130.

For *tests for identity* and for *impurities* see diacetylmorphine.

Remarks.—This hydrochloride is the heroin compound in general use, it having the advantage over the free alkaloid of being very soluble in water.

Dose.—3 milligrammes (1/20 grain).

ÆTHYLMORPHINÆ HYDROCHLORIDUM—Ethylmorphine Hydrochloride

(Æthylmorph. Hydrochl.—Ethylmorphine Chloride)

The hydrochloride [$C_{19}H_{23}NO_3HCl+2H_2O$ or $C_{17}H_{17}NO(OH)(OC_2H_5).HCl+2H_2O=385.69$] of an alkaloid prepared from morphine by ethylation. Preserve it in well-closed containers, protected from light.

Summarized Description.

White or yellowish, odorless, microcrystalline powder; soluble in about 8 parts of water and in about 17 parts of alcohol; slightly soluble in chloroform and ether; melts at 123°C., with decomposition. For details, see U.S.P., p. 34.

Color Test.—Green, then violet blue, when warmed with ferric chloride and sulphuric acid. Deep red, when foregoing mixture is treated with nitric acid.

Impurities.—Ammonium compounds (no alkaline vapors on heating with potassium hydroxide solution.) Morphine (no blue or green color with potassium ferricyanide—ferric chloride reagent. For details, see U.S.P., p. 35.

Remarks.—This new official synthetic is largely used under the trade name, *dionin.* It is made by the action of ethyl iodide on morphine in the presence of alkali. Like heroin, it has been claimed to be devoid of the objectionable qualities of morphine.

Dose.—15 milligrammes (1/4 grain).

Apomorphine.—This interesting artificial alkaloid is prepared by heating morphine with concentrated hydrochloric acid in sealed tubes to 150°C. The sealed tubes in this case are tubes of glass about a quarter of an inch thick and 3 feet long, originally in the shape of an ordinary test-tube. The ingredients are placed in this tube, and then the upper portion is drawn to a fine point by heating in a blast lamp flame. In this way the ingredients are sealed within the walls of glass. This tube is then wrapped up in paper and placed within an iron tube, stopped at one end with an appropriate cap. This tube is then placed in a suitable oven and is heated for the requisite time, and after cooling for a time the sealed tip is opened cautiously to permit the escape of the compressed gases, and is finally broken by cutting with a glass file.

The formula for apomorphine differs from that of morphine simply by the loss of one molecule of water, which is removed by the action of concentrated hydrochloric acid, as mentioned above.

APOMORPHINÆ HYDROCHLORIDUM—
Apomorphine Hydrochloride

(Apomorph. Hydrochl.—Apomorphine Chloride)

The hydrochloride [$C_{17}H_{17}NO_2HCl+\frac{1}{2}H_2O=312.62$] of an alkaloid prepared from morphine by the abstraction of one molecule of water. Preserve it, protected from light, in small, well-stoppered vials, which have been previously rinsed with diluted hydrochloric acid and dried.

Apomorphine Hydrochloride must be rejected if it imparts at once an emerald-green color to 100 parts of distilled water when shaken with it in a test tube.

Summarized Description.

Minute white or grayish-white, glistening monoclinic prisms; turns green on exposure to light and air; soluble in about 50 parts of water and about 40 parts of alcohol; slightly soluble in chloroform or ether. For details see U.S.P., p. 51.

For *tests for identity* and for *impurities:* Decomposition products (ethereal solution not more than pale reddish). See U.S.P., p. 52.

Remarks.—Apomorphine hydrochloride dissolves in water in a colorless solution, but on standing it changes to a greenish tint. The nature of the decomposition is not yet fully understood, but is worth bearing in mind in prescription practice since a green solution should not be dispensed. This alkaloid salt is emetic, being of particular value employed hypodermically in cases of attempted suicide by poisoning.

Dose.—Expectorant, 3 milligrammes ($\frac{1}{20}$ grain); emetic, by mouth, 10 milligrammes ($\frac{1}{6}$ grain); emetic, hypodermic, 5 milligrammes ($\frac{1}{12}$ grains).

CODEINA—Codeine

(Codein.)

An alkaloid [$C_{18}H_{21}NO_3+H_2O$ or $C_{17}H_{18}(CH_3)NO_3+H_2O=317.19$] obtained from opium, or prepared from morphine by methylation. Preserve it in well-closed containers protected from light.

Summarized Description.

Colorless, translucent slightly efflorescent rhombic prisms or crystalline powder; soluble in about 120 parts of water and in about 1.6 parts of alcohol; also soluble in chloroform and ether; aqueous solution is lævorotatory; when dried melts between 154° and 156°C.

Color Tests.—Green, then blue, then grass-green, with sulphuric acid-selenous acid reagent. Not more than faint pink with sulphuric acid; then blue by adding ferric chloride, then red by adding nitric acid. For details see U.S.P., p. 118.

Impurities.—Morphine (not green nor blue with potassium ferricyanide—ferric chloride reagent) see U.S.P.

Extraction.—The aqueous infusion of opium is concentrated and treated with calcium chloride, which holds the alkaloids in solution as hydrochlorides, while the meconic acid, color, etc., are precipitated. The filtrate is concentrated, when the hydrochlorides of codeine and morphine crystallize. The mixed salts are redissolved in water and the solution made alkaline with ammonia, which precipitates the morphine. The filtrate on concentration yields crystals of codeine hydrochloride, and the free alkaloid is obtained from this by treatment with potassa. The above process is also another of the many methods for obtaining morphine from opium.

Remarks.—Codeine is another of the numerous alkaloids found in opium, and can be obtained synthetically by treatment of morphine with potassium hydroxide and methyl iodide. This synthesis and other investigations show that it is methyl ether of morphine.

Characteristic reactions of codeine are, as of many alkaloids already studied, the behavior of the substance with concentrated sulphuric acid and various oxidizing or reducing agents, such as nitric acid, ferric chloride, selenous acid, and formaldehyde. These tests are of value in distinguishing codeine from morphine, as is also the fact that codeine turns yellow with nitric acid and *not* red, as does morphine.

Dose.—30 milligrammes (½ grain).

CODEINÆ PHOSPHAS—Codeine Phosphate

(Codein. Phos.)

The phosphate [$C_{18}H_{21}NO_3.H_3PO_4+2H_2O$ or $C_{17}H_{18}(CH_3)NO_3.H_3PO_4+2H_2O = 433.27$] of the alkaloid codeine. It yields not less than 67 per cent. of anhydrous codeine ($C_{18}H_{21}NO_3$). Preserve it in well-closed containers, protected from light.

Summarized Description.

Fine, white, efflorescent needle-shaped crystals or crystalline powder; soluble in about 2.3 parts of water and in about 261 parts of alcohol; sparingly soluble in chloroform and ether; for *tests for identity* and for *impurities*, see codeine.

Outline of Assay.—Dissolve the salt, make the solution alkaline with potassium hydroxide and shake out three times with chloroform. Evaporate the chloroformic extract, dry and weigh the residue. Yield should be not less than 67 per cent. of the original sample. For details, see U.S.P.

Dose.—30 milligrammes (½ grain).

CODEINÆ SULPHAS—Codeine Sulphate

(Codein. Sulph.)

The sulphate [$(C_{18}H_{21}NO_3)_2.H_2SO_4+5H_2O$ or $(C_{17}H_{18}(CH_3)NO_3)_2.H_2SO_4+5H_2O=786.52$] of the alkaloid codeine. Preserve it in well-closed containers, protected from light.

Summarized Description.

Long, white glistening, white, needle-shaped efflorescent crystals or crystalline powder; soluble in about 30 parts of water and in about 1035 parts of alcohol, insoluble in chloroform or ether; gives the barium chloride test for sulphates.

For *tests for identity* and for *impurities*, see Codeine.

Remarks.—The uncombined alkaloid, as well as the phosphate and the sulphate, are official, and these are used as sedatives in cough-mixtures and the like, being administered in much larger doses than is morphine and its salts—one-half grain being considered as a safe dose of any of three official forms.

Dose.—30 milligrammes (½ grain).

COTARNINÆ HYDROCHLORIDUM—Cotarnine Hydrochloride

(Cotarn. Hydrochl.—Cotarnine Chloride)

Quaternary oxymethyl-oxymethylene-dihydro-isoquinoline chloride [$C_{12}H_{14}NO_4Cl$ or $(CH_3O)\ (CH_2O_2).C_9H_6N\ (CH_3)Cl=255.58$] obtained by hydrolyzing narcotine, and treating the resulting cotarnine [$(CH_3O)\ (CH_2O_2)C_8H_5(CHO).NH(CH_3)$] with hydrochloric acid.

Summarized Description.

Yellow, deliquescent, crystalline powder very soluble in water and in alcohol. For details, see U.S.P., p. 124.

For *tests for identity* see U.S.P.

Remarks.—This new official synthetic is known in commerce as *stypticin.* As the name suggests, it is a derivative of narcotine; being made from the latter alkaloid by oxidization with diluted nitric acid.

Stypticin is used as a hemostatic analgesic and uterine sedative.

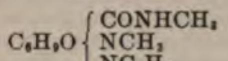
Dose.—60 milligrammes (1 grain).

Styptol is cotarnine phthalate. It is a yellow powder used like stypticin.

Dose.—45 milligrammes (¾ grain).

GROUP VI.—ALKALOIDS WHOSE STRUCTURE IS LITTLE UNDERSTOOD

Physostigmine.—About all we know of the structure of this alkaloid can be expressed in the following formula:



$$C_6H_9O\left\{\begin{array}{l}CONHCH_3\\ NCH_3\\ NC_6H_5\end{array}\right.$$

A characteristic reaction of physostigmine is the red-blue color-play produced when its ammonium hydroxide solution is evaporated on a water-bath and acidified with acetic acid; as well as the color produced with nitric acid.

The alkaloid is extracted from calabar bean by extracting same in fine powder with warm alcohol containing 0.1 per cent. tartaric acid. The alcohol is distilled from the tincture, the residue treated with water, the filtrate shaken with ether to remove color, and then made alkaline with potassium bicarbonate, and again shaken out with ether, which this time extracts the free alkaloid, which is obtained by evaporation of the ethereal solution.

Physostigmine, or *eserine,* as it is sometimes called, is recognized by the pharmacopœia in the form of salicylate.

PHYSOSTIGMINÆ SALICYLAS—Physostigmine Salicylate

(Physostig. Salicyl.—Eserine Salicylate)

The salicylate [$C_{15}H_{21}O_2N_3.C_7H_6O_3=413.25$] of an alkaloid obtained from physostigma. Preserve it in small, well-closed containers, protected from light.

Summarized Descrintion.

Colorless or faint yellow, shining, acicular or short columnar crystals; turns red on exposure to light and air; very poisonous; soluble in about 75 parts of water and in about 12.7 parts of alcohol and in about 8.6 parts of chloroform; less soluble in ether. For details see U.S.P., p. 320.

For *tests for identity* and for *impurities.* Sulphate (barium chloride test). Readily carbonizable matter (sulphuric acid solution not darker than yellow), see U.S.P.

Remarks.—Salts of physostigmine are very deliquescent, and the pharmacist is warned against buying even so small a quantity as a gramme unless the whole quantity is to be dispensed at one time; nor is it advisable to keep the physostigmine salts in solution, as the originally colorless solution turns a dark red. One of the largest manufacturers of alkaloids now dispenses physostigmine in one-grain tubes, which are sealed by a blow-pipe, thus precluding all contact with the atmosphere. Such is the only way that the pharmacist should keep eserine in stock.

Physostigmine salts are used almost entirely as miotics—that is, for producing contraction of the pupil of the eye. If given internally, they are used as tonics.

Dose.—1 milligramme (1/60 grain).

ACONITINA—Aconitine

(Aconitin.)

An alkaloid [$C_{34}H_{47}NO_{11} = 645.39$] obtained from aconite. Preserve it in well-closed containers protected from light.

Summarized Description.

Colorless or white rhombic tables or prisms; extremely poisonous; highly diluted (1 in 100,000) gives tingling and numbing sensation to the tongue; soluble in about 3200 parts of water, in about 22 parts of alcohol and in about 5.6 parts of benzene; less soluble in ether; almost insoluble in petroleum benzin; melts at about 195°C. For details see U.S.P., p. 28.

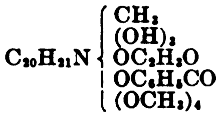
Color Tests.—No color with nitric or sulphuric acid. Orange with sulphuric acid—ammonium vanadate reagent. For details see U.S.P.

Impurities.—Pseudocontine or atropine (no violet color on treatment with nitric acid, followed by alcoholic potassium hydroxide) see U.S.P.

Extraction.—Powdered aconite is exhausted with amyl alcohol and the percolate shaken out with 0.2 per cent. sulphuric acid. The acid solution is freed from resin and other impurities by shaking with ether, and is then made alkaline with sodium carbonate and shaken out with ether.

The crude alkaloid obtained by evaporation of the ethereal solution is purified by recrystallization from ether or from alcohol.

Composition.—Investigations of aconitine have developed its formula to the extent shown below:



$$C_{20}H_{21}N\left\{\begin{array}{l}CH_3\\(OH)_3\\OC_2H_3O\\OC_6H_5CO\\(OCH_3)_4\end{array}\right.$$

Remarks.—This chemical is interesting as being the most potent official substance, being administered in the smallest dose. In fact, its use internally is not advisable.

Medical Properties.—Like aconite.

Dose.—0.15 milligramme (1/400 grain).

COLCHICINA—Colchicine

An alkaloid [$C_{22}H_{25}NO_6 = 399.21$] obtained from colchicum. Preserve it in well-closed containers, protected from light.

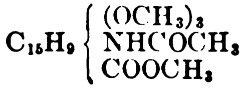
Summarized Description.

Pale yellow amorphous scales or pale yellow amorphous powder, darkens on exposure to light; extremely poisonous; soluble in about 22 parts of water; very soluble in alcohol and in chloroform; less soluble in ether and benzene; insoluble in petroleum benzin; aqueous solution is lævorotatory and of a yellow color; melts between 142° and 146°C. For details see U.S.P., p. 120.

For *tests for identity* and for *impurities:* Colchiceine (aqueous solution not colored by ferric chloride solution). Chloroform (the isonitrile reaction) see U.S.P., p. 121.

Extraction.—Powdered colchicum seed are extracted with 90 per cent. hot alcohol, the alcohol recovered by distillation, and the residue treated with water. The filtrate is shaken out with chloroform, the chloroformic solution of the alkaloid evaporated, the residue dissolved in water, and again shaken out with chloroform. On evaporation of the solvent a crystalline chloroformic compound of colchicine is left, and this is dissolved in alcohol, concentrated by distillation, again shaken out with chloroform, and the chloroform distilled off. The residue is dissolved in warm ether, and the colchicine-chloroform crystals mixed with water and warmed until the chloroform evaporates. The aqueous solution of purified colchicine is then evaporated to dryness. The shaking out with several portions of chloroform is necessary to free the colchicine from brown coloring-matter.

Composition.—



$$C_{15}H_9\left\{\begin{array}{l}(OCH_3)_3\\NHCOCH_3\\COOCH_3\end{array}\right.$$

Medical Properties.—Like colchicum (p. 829).

Dose.—½ milligramme (1/20 grain).

PELLETIERINÆ TANNAS—Pelletierine Tannate

(Pellet. Tann.)

A mixture in varying proportions of the tannates of four alkaloids (punicine, isopunicine, methyl-punicine, and pseudo-punicine), obtained from pomegranate. Preserve it in small, well-closed containers, protected from light.

Summarized Description.

Light yellow, odorless, amorphous powder; astringent taste; soluble in about 240 parts of water and in about 12.6 parts of alcohol; less soluble in ether; insoluble in chloroform. For details see U.S.P., p. 311.

For *tests for identity* and for *impurities:* Foreign alkaloids (acidulated solution not precipitated by platinic chloride) see U.S.P.

Manufacture.—Ground pomegranate bark is mixed with milk of lime and extracted with water. The percolate is shaken with chloroform and the separated chloroformic layer is shaken with diluted sulphuric acid. The acid solution of the sulphates of the alkaloids is treated with tannic acid and the precipitated tannates collected on a filter and dried.

Composition.—As mentioned in the official definition given above, this body is a mixture of four alkaloids each of which resembles the tropines in structure. The free alkaloidal mixture is a volatile liquid, but the official tannate, like all salts of liquid alkaloids, is a solid.

Medical Properties.—Tenifuge.

Dose.—250 milligrammes (4 grains).

EMETINÆ HYDROCHLORIDUM—Emetine Hydrochloride

(Emet. Hydrochl.)

The hydrochloride [$C_{30}H_{44}N_2O_4.2HCl = 569.31$] of the alkaloid emetine, obtained from ipecac. It contains variable amounts of water of crystallization. Preserve it in dark amber-colored vials protected from light.

Summarized Description.

White or slightly yellow crystalline powder, darkening on exposure to light; freely soluble in water or alcohol; does not lose more than 19 per cent. of its original weight at 100°C. For details see U.S.P., p. 133.

Color Test.—Bright green with sulphuric acid—molybdic acid reagent.

Impurities.—Readily carbonizable matter (color of sulphuric acid solution not more than faint yellow). Cephælin (aqueous alkaline mixture is shaken out with ether and then acidulated, made alkaline with ammonia and again shaken out with ether. This second ethereal extract is not made purple by sulphuric acid—molybdic acid reagent). For details see U.S.P., p. 133.

Remarks.—This alkaloid of ipecac has lately come into tremendous vogue both as a remedy for amebic dysentery and for pyorrhea, the distressing dental infection.

Dose.—Hypodermic, 20 milligrammes (⅓ grain).

ALKALOIDAL DRUGS

IPECACUANHA—Ipecac

(Ipecac.—Ipecacuanhæ radix P.I.)

The dried root of *Cephaelis Ipecacuanha* (Brotero) A. Richard, known in commerce as Rio Ipecac, or of *Cephaelis acuminata* Karsten, known in commerce as Cartagena Ipecac (Fam. *Rubiaceæ*), without the presence or admixture of more than 5 per cent. of stems and yielding not less than 1.75 per cent. of the ether-soluble alkaloids of Ipecac.

Assay.—Part V (p. 910).

Constituents.—Emetine, cephaëline, psychotrine ipecacuanhic acid (a form of tannin), a phytosterol, starch, etc.

Medical Properties.—Expectorant or emetic, according to dose. Official preparations: *Fluidextract* (p. 245) and *Dover's powder* (p. 293). The fluidextract is a constituent of the *syrup* (p. 197).

Dose.—Of drug: Expectorant, 65 milligrammes (1 grain); emetic, 1 gramme (15 grains).

GELSEMIUM—Gelsemium

(**Gelsem.**—Yellow Jasmine Root—Yellow Jessamine)

The dried rhizome and roots of *Gelsemium sempervirens* (Linné) Aiton filius (Fam. *Loganiaceæ*).

Constituents.—Alkaloids (*gelsemine, gelseminine, sempervirine*, etc.) *scopoletin* (the mono-methyl-ester of esculetin, formerly called *gelseminic acid*), volatile oil, resin (consisting of a phytosterol; pentatriacontane, $C_{35}H_{72}$; and ipuranol, $C_{23}H_{38}O_2(OH)_2$; combined oleic, palmitic, stearic and linolic acids), etc.

Medical Properties.—Antipyretic, etc. The *tincture* (p. 227) and *fluidextract* (p. 244) and the *extract* (p. 276) are official.

Dose.—30 milligrammes (½ grain).

Pareira (U.S.P. VIII; N.F. IV) is the dried roots of *Chondrodendron tomentosum* Ruiz et Pavon (Fam. *Menispermaceæ*).

The drug contains alkaloids (bebeerine, isobebeerine, chondodendron, etc.), fat, starch, and tannin. It is used as a simple bitter, diuretic, in 30-grain doses.

ACONITUM—Aconite

(**Aconit.**—Monkshood—Aconite Root—Aconiti tuber P.I.)

The dried tuberous root of *Aconitum Napellus* Linné (Fam. *Ranunculaceæ*), without admixture of more than 5 per cent. of stems and other foreign matter, and yielding not less than 0.5 per cent. of the ether-soluble alkaloids of Aconite. If made into fluidextract and assayed biologically the minimum lethal dose should not be greater than 0.00004 mil for each gramme of body weight of guinea-pig.

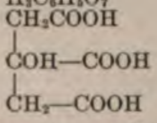
Assay.—Part V (p. 909).

Constituents.—Aconitine, nepelline, aconitic acid, etc. *Aconitine* consists of true aconitine, pseudoaconitine, aconine, pseudaconine, picraconitine, etc.

Remarks.—Aconite is a tuberous root from the Ranunculaceæ, or crowfoot family. Its well-known poisonous property is due to its alkaloid, aconitine, which is supposed to exist in the root as the salt of aconitic acid. This acid is closely allied to citric acid, as a side-by-side comparison formula will show:

Citric acid.

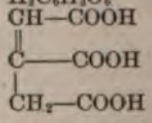
$H_3C_6H_5O_7$



$$\begin{array}{l} CH_2COOH \\ | \\ COH{-}COOH \\ | \\ CH_2{-}COOH \end{array}$$

Aconitic acid.

$H_3C_6H_3O_6$



$$\begin{array}{l} CH{-}COOH \\ \| \\ C{-\!-}COOH \\ | \\ CH_2{-}COOH \end{array}$$

Like citric acid, aconitic acid is not poisonous. It is found in several plants other than aconite; for instance, sorghum and yarrow.

Medical Properties.—Of value in fevers produced from colds, neuralgia, etc. Locally as a local irritant and anesthetic. The *tincture* (p. 222) *fluidextract* (p. 245) and extract (p. 273) are official.

Dose.—30 milligrammes (½ grain).

Berberis (U.S.P. VIII; N.F. IV), or *Oregon grape root*, is "the rhizome and roots of species of the section *Odostemon* Rafinasque of the genus *Berberis* Linné." It contains *berberine*, $C_{20}H_{17}NO_4$ (p. 819), *oxyacanthine*, $C_{19}H_{21}NO_3$, *berbamine*, $C_{18}H_{19}NO_3$, etc. It is used as a tonic and stimulant in 30-grain doses.

COLCHICI CORMUS—Colchicum Corm

(Colch. Corm.—Colchicum Root)

The dried corm of *Colchicum autumnale* Linné (Fam. *Liliaceæ*), yielding not less than 0.35 per cent. of colchicine.

Assay.—See p. 908.

Constituents.—*Colchicine, colchiceine*, fat, gum, starch, inulin, etc.

Remarks.—Colchicum is official in two forms: the "corm" and the seed of *Colchicum autumnale*, a pretty little liliaceous plant called "meadow-saffron," that decks the pastures of South Germany with beautiful pink flowers during the month of September. A "corm" is a variety of tuber, the most familiar example of a tuber being the Irish potato. The potato grows underground, but it is not a root, for, bear in mind, that is an erroneous impression that an underground plant part has to be a root. The difference between a root and a stem is that while the latter *always* bears leaves, the former *never* does. The potato must, therefore, be a stem part, for it bears leaves, the "eyes" of the potato being minute leaf groups, which sprout under favorable circumstances. Such a thick, fleshy stem part, growing underground and designed as the storehouse for food for the next year's growth, is called a tuber, and colchicum root is a modification of a tuber called a corm. A corm differs from a tuber by growing at the immediate base of the stem instead of at the end of a subterranean shoot, as the regular tuber does.

Medical Properties.—Of great value in gout. Its use, however, must not be long continued, as it soon irritates the stomach and intestines.

The *extract* (p. 274) is official.

Dose.—Of drug, 250 milligrammes (4 grains).

COLCHICI SEMEN—Colchicum Seed

(Colch. Sem.—Colchici semen P.I.)

The dried seeds of *Colchicum autumnale* Linné (Fam. *Liliaceæ*), yielding not less than 0.45 per cent. of colchicine.

Assay.—See p. 908.

Constituents.—*Colchicine, colchiceine*, fruit sugar, mucilage, tannin, fixed oil (6 to 8 per cent.)

Mecical Properties.—Like the corm. The *tincture* (p. 226), and *fluidextract* (p. 244) are official.

Dose.—200 milligrammes (3 grains).

SANGUINARIA—Sanguinaria

(Sanguin.—Blood Root)

The dried rhizome and roots of *Sanguinaria canadensis* Linné (Fam. *Papaveraceæ*).

Constituents.—*Sanguinarine, chelerythrine, protopine, berberine*, resins, etc.

Remarks.—The drug is called blood root because, in the spring, the fresh rhizome, when broken, exudes a red juice. Likewise the dried drug is deep red in the interior.

Medical Properties.—Nauseant expectorant. The *tincture* (p. 232) is official.

Dose.—125 milligrammes (2 grains).

SPIGELIA—Spigelia

(Pinkroot)

The dried rhizome and roots of *Spigelia marilandica* Linné (Fam. *Loganiaceæ*), without the presence or admixture of more than 10 per cent. of stems or other foreign matter.

Constituents.—*Spigeline* (volatile alkaloid), volatile oil, resins, etc.

Medical Properties.—Vermifuge. Administered as *fluidextract*, U.S.P. (p. 244).

Dose.—4 grammes (60 grains).

HYDRASTIS—Hydrastis

(Golden Seal)

The dried rhizome and roots of *Hydrastis canadensis* Linné (Fam. *Ranunculaceæ*), without the presence or admixture of more than 2 per cent. of the stems, leaves and other foreign matter and yielding not less than 2.5 per cent. of the ether-soluble alkaloids of Hydrastis.

Constituents.—*Hydrastine, berberine, canadine,* resin, starch, etc.

Remarks.—Hydrastis, the rhizome and rootlets of *Hydrastis canadensis*, is an American drug, which has obtained world-wide reputation. Note its two leading constituents, of which the hydrastine should be white. Hydrastine is very expensive, hence the cheap yellow berberine is often substituted for it. Note that it is berberine which gives the drug the characteristic yellow color, which suggested the synonym, golden seal.

Medical Properties.—Bitter stomachic, useful in catarrhal trouble, hence of value as injection in gonorrhea. For this purpose the official *glycerite* (p. 211) is largely used. The *tincture* (p. 228), the *extract* (p. 277) and the *fluidextract* (p. 245) are also official.

Dose.—2 grammes (30 grains).

VERATRUM VIRIDE—Veratrum Viride

(Verat. Vir.—Green Hellebore—American Hellebore)

The dried rhizome and roots of *Veratrum viride* Aiton (Fam. *Liliaceæ*), without the presence or admixture of more than 5 per cent. of stems or other foreign matter.

Constituents.—*Jervine, pseudojervine, rubijervine, veratroidine, cevadine.* White veratrum contains veratrine and also the alkaloids above mentioned. The official veratrine comes from cevadilla seed (p. 817).

Remarks.—While the last pharmacopœia recognized both American hellebore and white hellebore under the title "Veratrum;" in the present edition, only veratrum viride is official. It is used as a sedative, emetic and diuretic.

Dose.—60 milligrammes (1 grain).

CINCHONA—Cinchona

(Cinch.—Yellow Cinchona—Calisaya Bark—Yellow Peruvian Bark)

The dried bark of *Cinchona Ledgeriana* Moens, *Cinchona Calisaya* Weddell, and of hybrids of these with other species of *Cinchona* (Fam. *Rubiaceæ*), yielding not less than 5 per cent. of the alkaloids of Cinchona.

CINCHONA RUBRA—Red Cinchona

(Cinch. Rub.—Red Peruvian Bark)

The dried bark of *Cinchona succirubra* Pavon (Fam. *Rubiaceæ*), or of its hybrids, yielding not less than 5 per cent. of the alkaloids of Red Cinchona.

Constituents.—Quinine, quinidine, cinchonine, cinchonidine, and many other alkaloids, kinic acid, kinovic acid, and cinchotannic acid.

Cinchona barks are alkaloidal drugs, whose value is scarcely second to opium. In these barks the pharmacopœia gives a wide range of selection, for, while dividing them into two groups—*cinchona* and *cinchona rubra*—that authority allows the use of any cinchona bark containing 6 per cent. of the alkaloids peculiar to the species. Under the heading "cinchona rubra" we find but one species allowed—Cinchona succirubra, the last word meaning "red juice." But under the head "cinchona" permission is given to use any cinchona yielding 6 per cent. of total alkaloids.

Time forbids an extended sketch of the origin and history of the cinchona barks, but the student is advised to read the subject in the dispensatories. Here need only be said that the general introduction of the bark was due to the Countess of Chinchon, wife of a viceroy of Peru, who was cured of malaria by the use of the drug in the sixteenth century, since when it has gained the esteem of the entire world. The reckless collection of the drug by chopping down wild trees, with no attempt to plant new ones in their stead, threatened the extermination of this valuable drug, but, fortunately, this danger was averted by the commencement of the systematic cultivation of the drug by the Dutch in Java and by the English in India, who have taken most of the business from its first home—Chile and Peru.

Note that of the large number of alkaloids separated from cinchona, but four—quinine, quinidine, cinchonine, cinchonidine—are worthy of careful study.

Note also that cinchona contains a large amount of tannin, hence glycerin is added to the menstruum in preparing its official preparations. This also explains the well-known prescription incompatibility, the inky liquid obtained by mixing preparations of cinchona with iron salts (p. 949); hence in preparing such pharmaceuticals as elixir of cinchona and iron the cinchona percolate must be "detannated" before adding the iron salt.

Mention must be made of a former official product of cinchona, which was dropped in the revision of 1890; a substance called *chinoidine.* In the days when quinine was worth $4 to $5 an ounce, a cheaper cinchona product was demanded. This was found in chinoidine, whose efficiency was due to the imperfect methods then employed in making quinine. Quinine is separated from the other cinchona alkaloids by crystallization, and in the old process, after the mother liquor had been concentrated several times, thus yielding most of the four official alkaloids, it was evaporated to a brown mass, still containing some of the four alkaloids, as well as all the minor bodies found in the bark. But the old-time primitive methods of extraction have given place to modern processes, by which almost all of the important alkaloids are won from the cinchona, leaving the mother liquor practically inert. Hence chinoidine of to-day is almost valueless and in the pharmacopœial revision of 1890 it was omitted.

Medical Properties.—Febrifuge (quinine is a specific in malarial fever), tonic astringent. Official preparations: Of red bark, *compound tincture* (p. 226), of yellow bark, *tincture* (p. 225) and *fluidextract* (p. 245).
Dose.—Of both barks, 1 gramme (15 grains).

GRANATUM—Pomegranate

(**Granat.**—Pomegranate Bark)

The dried bark of the stems and roots of *Punica Granatum* Linné (Fam. *Punicaceæ*), without the presence or admixture of more than 2 per cent. of wood and other foreign matter. Preserve it in tightly closed containers.

Constituents.—*Pelletierine,* U.S.P. punicotannic acid.
Remarks.—Note that the official drug is the bark of the stem and root, not the rind of the fruit, which is so popular in the southern States, as a dysentery remedy.
Medical Property.—Tenifuge. Administered preferably as the alkaloid pelletierine, or as *fluidextract,* U.S.P. (p. 245).
Dose.—Of drug, 2 grammes (30 grains).

ASPIDOSPERMA—Aspidosperma

(**Aspidosp.**—Quebracho)

The dried bark of *Aspidosperma Querbracho blanco* Schlechtendal (Fam. *Apocynaceæ*), without admixture of more than 2 per cent. of wood and other foreign matter.

Constituents.—Alkaloids (*aspidospermin, aspidospermatine, quebrachine,* etc.), quebrachol, $C_{20}H_{34}O$; quebrachit, $C_6H_{11}(OCH_3)O_5$, tannin.
Remarks.—This drug, which was recognized in U.S.P. 1890 and which was deleted from the last pharmacopœia, has again become official. It is a tonic and is considerably esteemed as a remedy for dysentery.
Dose.—4 grammes (60 grains).

PILOCARPUS—Pilocarpus

(**Pilocarp.**—Jaborandi)

The dried leaflets of *Pilocarpus Jaborandi* Holmes, known in commerce as Pernambuco Jaborandi, or of *Pilocarpus microphyllus* Stapf, known in commerce as Maranham Jaborandi (Fam. *Rutaceæ*), without the presence or admixture of more than 5 per cent. of the stalks bearing the leaflets and stems of the same plant, or other matter, and yielding not less than 0.6 per cent. of the alkaloids of Pilocarpus.
Assay.—See Part V (p. 911).

Constituents.—Alkaloids (*pilocarpine, isopilocarpine, pilocarpidine, carpilline,* etc.) volatile oil; resin, etc.
Medical Properties.—Valuable diaphoretic and sialagogue. Administered in the form of the official *fluidextract* (p. 244).
Dose.—2 grammes (30 grains).

Coca (U.S.P. VIII) is the dried leaflets of *Erythroxylon Coca* and *Erythroxylon Truxillense.* The drug contains *cocaine, hygrine,* cocatannic acid, etc. It has been used by the natives of Peru, since the earliest times as a stimulant. The Indians chew the leaves mixed with ashes, and are then capable of performing such hard tasks as climbing mountains with loaded backs, practically abstaining from food during the trip. Its use as a tonic in Europe and North America covers a period of many years, but its great consumption began in the early eighties, with the discovery of the remarkable local anesthetic action of its alkaloid, cocaine, made official in 1890 in the form of *cocaine hydrochloride*. The frightful abuse of cocaine has extended to coca leaves as well; hence the revision committee decided to delete from the present pharmacopœia, coca and all of its preparations.

Coca, as suggested above, is used as a stimulant, in 30-grain doses.

BELLADONNÆ FOLIA—Belladonna Leaves

(**Bellad. Fol.**—Deadly Nightshade Leaves—Belladonnæ folium P. I.)

The dried leaves and tops of *Atropa Belladonna* Linné (Fam. *Solanaceæ*), without admixture of more than 10 per cent. of its stems, or other foreign matter and yielding not less than 0.3 per cent. of the total alkaloids from Belladonna Leaves.

Constituents.—*Atropine, hyoscyamine, belladonnine,* and other alkaloids, chlorophyll, etc.

Remarks.—Belladonna is derived from the "deadly nightshade," *Atropa Belladonna,* the leaves and root of which are official. Both contain atropine, which dilates the pupil of the eye, making it large and lustrous. From this property the drug gets its name, which is Italian for "pretty lady." Besides atropine, the drug contains two other official alkaloids, hyoscyamine and hyoscine, these two being, of course, named after hyoscyamus, in which they are first found. All three of these alkaloids are found in various proportions in many of the plants of the Solanaceæ—the nightshade family—to which both belladonna and hyoscyamus belong, and all three, by reason of the property of dilating the pupil, are called the *mydriatic alkaloids.* Hyoscyamine and atropine are isomeres—both have the same chemical formula. In fact, so similar are they that they can be distinguished only by the differing behavior of their gold salts.

Medical Properties.—Stimulates the higher centers, hence used in asthma and to quicken the pulse; used to modify the action of vegetable purgatives, as is shown in the official *compound laxative pills,* in which extract of belladonna leaves is employed. Used externally in neuralgia. Official preparations: the *extract* (p. 273) and the *tincture* (p. 224). From the extract the *ointment* (p. 332) is made.

Dose.—60 milligrammes (1 grain).

BELLADONNÆ RADIX—Belladonna Root

(**Bellad. Rad.**—Deadly Nightshade Root)

The dried root of *Atropa Belladonna* Linné (Fam. *Solanaceæ*), without admixture of more than 10 per cent. of its stem-bases and yielding not less than 0.45 per cent. of the total alkaloids from Belladonna Root. Preserve Belladonna Root in tightly closed containers adding a few drops of chloroform or carbon tetrachloride from time to time to prevent attack by insects.

Constituents.—Like the leaves, except for absence of chlorophyll.

Remarks.—Note that the root contains more mydriatic alkaloids than do the leaves (root, $^{45}/_{100}$ of 1 per cent.; leaves, $^{3}/_{10}$ of 1 per cent.), hence it is administered in smaller dose.

Medical Properties.—Like the leaves. The *fluidextract* (p. 243) is official, and from it is made the official *liniment* (p. 265).

Dose.—Of drug, 45 milligrammes ($^{3}/_{4}$ grain).

STRAMONIUM—Stramonium

(**Stramon.**—Jamestown Weed—Jimson Weed)

The dried leaves of *Datura Stramonium* Linné, or of *Datura Tatula* Linné (Fam. *Solanaceæ*), without the presence or admixture of more than 10 per cent. of stems or other foreign matter, and yielding not less than 0.25 per cent. of the total alkaloids of Stramonium.

Constituents.—Atropine, hyoscine, hyoscyamine, chlorophyll. The constituent *daturine* has been proved a mixture of atropine and hyoscyamine.

Remarks.—Stramonium is the leaves of *Datura Stramonium*, which is the well-known "jimson weed," a plant growing all over the United States, Europe, and Asia. It is said that the plant has become so widely distributed through those curious people, the gypsies, who travel all over the world, carrying with them stramonium seed—for criminal uses it is said. It is also claimed that it was the active constituent of the witches' brew of medieval times. Note that stramonium belongs to that plant family called the Solanaceæ, or nightshade family, which furnishes such valuable drugs as belladonna and hyoscyamus, and also includes several of our best known vegetables, like Irish potato, tomato, and egg-plant.

Belladonna, hyoscyamus, and stramonium contain the three mydriatic alkaloids, atropine, hyoscine, and hyoscyamine. Quite often we find such chemical similarities existing between members of the same plant family—a very striking fact when we consider that the method by which we classify plants has nothing to do with chemistry.

Medical Properties.—Like belladonna. The *extract* (p. 279) and the *tincture* (p. 233), are official. From the extract, the official *ointment* (p. 334) is prepared.

Dose.—60 milligrammes (1 grain).

Stramonium seeds, which were recognized by the pharmacopœia of 1890, never enjoyed the same popularity as the leaves, hence were dropped from the eighth edition. They contained the same alkaloids and were used similarly to the leaves and given in the same dose.

HYOSCYAMUS—Hyoscyamus

(**Hyosc.**—Henbane—Hyoscyami folium P. I.)

The dried leaves and flowering or fruiting tops of *Hyoscyamus niger* Linné (Fam. *Solanaceæ*), yielding not less than 0.065 per cent. of the alkaloids of Hyoscyamus.

Constituents.—Hyoscyamine and hyoscine.

Remarks.—Hyoscyamus is commonly called henbane, the official drug being leaves plucked from the second-year stem, those of the first year being small and almost inert. Note that the drug is much weaker in mydriatic alkaloids than are belladonna and stramonium leaves, the last two being required to contain respectively $^{3}/_{10}$ and $^{25}/_{100}$ of 1 per cent. of alkaloids, while the requirement for hyoscyamus is but $^{65}/_{1000}$ of 1 per cent.

Medical Properties.—Similar to belladonna, but preferable to the latter drug in insomnia and for relieving the excitement of insanity. Official preparations: *Extract* (p. 278), *fluidextract* (p. 244), and *tincture* (p. 228). The fresh leaves steeped in a fixed oil along with other drugs and aromatics is highly popular in Europe under the name *Baume Tranquille*, as a remedy for earache and for general use as a liniment. See *infused oil of hyoscyamus*, N. F.

Dose.—Of drug, 250 milligrammes (4 grains).

Scopola (U.S.P. VIII) is the dried rhizome of *Scopola Carniolica.* It contains *scopolamine* (identical with hyoscine); some *hyoscyamine;* fat, sugar, fluorescent substance, etc. It was accorded pharmacopœial recognition as a source of scopolamine and because its extract is used by some plaster-makers for their so-called belladonna plasters. If used, it is, like belladonna and hyoscyamus, a sedative and narcotic. *Dose,* $^{3}/_{4}$ grain.

Tobacco, the leaves of *Nicotiana tabacum*, was official in former pharmacopœias, but was dropped in the last revision. It was formerly highly esteemed as a vulnerary, but is little used as a drug by intelligent physicians. A decoction of tobacco in which corrosive sublimate has been dissolved makes a satisfactory *bedbug poison*.

LOBELIA—Lobelia

(Lobel.—Indian Tobacco)

The dried leaves and flowering tops of *Lobelia inflata* Linné (Fam. *Lobeliaceæ*), without the presence or admixture of more than 10 per cent. of stems and other foreign matter.

Constituents.—*Lobeline* (a liquid alkaloid), *lobelic acid*, resin, etc.

Remarks.—Lobelia, or *Indian tobacco*, is a remedy highly esteemed by the natives and early colonists of North America. It was brought into medical prominence largely through the efforts of eclectic practitioners.

Medical Properties.—Expectorant and emetic. Poisonous in large doses. The *tincture* (p. 229) and the *fluidextract* (p. 245) are official.

Dose.—150 milligrammes (2½ grains).

Scoparius (U.S.P. VIII; N.F. IV), or *broomtops*, is the dried tops of *Cytisus Scoparius* (Linné) Link (Fam. *Leguminosæ*). The drug contains *sparteine* (liquid alkaloid), *scoparin* (neutral principle), volatile oil, tannin, etc. Broom is the "planta genista," from which the famous Plantagenet family took its name. It is not the broom-straw from which the modern American brooms used in sweeping are made, albeit a certain druggist was once known to fill a prescription for "decoction of broom" from the straw of that homely domestic article. Scoparius is used as a diuretic, its action being due to scoparin, rather than to sparteine. *Dose*, 15 grains.

Chelidonium.—The entire plant, *Chelidonium majus*, was official in the pharmacopœia of 1890. It, like the plant yielding opium, belongs to the natural order Papaveraceæ, the poppy family, and its juice also is somewhat narcotic. The drug is not used very largely. To the poppy family belongs also sanguinaria.

Conium (U.S.P. VIII; N.F. IV) is the full-grown but unripe fruit of *Conium maculatum*. It contains coniine, conhydrine, a trace of volatile oil, and fixed oil. It, like anise, coriander, fennel, and caraway, is a fruit of the natural order Umbellifera, and closely resembles anise in appearance—so much so that it has been confused with that drug, and with serious results. Unlike the four fruits just mentioned, it contains little or no aromatic oil, and does contain the poisonous liquid alkaloid coniine. This alkaloid has the peculiar odor of mice's urine, thus affording a good method of distinguishing conium from anise. Conium is that "seed," or, more correctly, that fruit, which, when triturated with solution of soda, gives off the odor of mice's urine. Conium is narcotic and sedative and is given in 3-grain doses.

NUX VOMICA—Nux Vomica

(Nux Vom.—Strychni semen P.I.)

The dried, ripe seeds of *Strychnos Nux-vomica* Linné (Fam. *Loganiaceæ*), yielding not less than 2.5 per cent. of the alkaloids of Nux Vomica.

Constituents.—*Strychnine, brucine, igasuric acid, loganine*, fat and albumin.

Remarks.—The "buttons" of nux vomica are very characteristic, and their silky appearance is due to the fine hairs with which they are covered. The fixed oil sometimes proves troublesome pharmaceutically, the alcoholic preparations frequently turning milky on addition of water.

Medical Properties.—Nervous stimulant and bitter tonic. Very poisonous. Antidote is chloral hydrate, which, however, merely lessens the force of the tetanic convulsions, and should be used only under direct supervision of the physician. In some respects a better antidote is an alkaloidal precipitant, such as tannin, compound solution of iodine, or potassium permanganate. The *extract* (p. 278), *tincture* (p. 230), and *fluidextract* (p. 244), of nux vomica are official.

Dose.—60 milligrammes (1 grain).

PHYSOSTIGMA—Physostigma

(**Physostig.**—Calabar Bean—Ordeal Bean)

The dried, ripe seeds of *Physostigma venenosum* Balfour (Fam. *Leguminosæ*) yielding not less than 0.15 per cent. of the alkaloids of Physostigma.

Constituents.—*Physostigmine* (or *eserine*), *physovenine*, $C_{14}H_{18}O_3N_2$, *calabarol*, $C_{23}H_{54}O_2(OH)_2$; phytosterols and other alcohols (trifolianol, stigmasterol, silosterol, glycerides of behenic, stearic, oleic, palmitic, linolenic acids, etc.

Remarks.—Physostigmine is called "Calabar bean," from that section of Africa where it grows. Its alkaloid, physostigmine, is official as the sulphate and as the salicylate, which is less deliquescent than the other salts (p. 825).

Medical Properties.—Similarly to strychnine, physostigmine (p. 825) is used for contracting the pupil of the eye—is a miotic, just the reverse of a mydriatic (p. 805). For this reason miotic drugs (like strychnine and physostigmine) have been suggested as antidotes to mydriatics (such as belladonna and hyoscyamus), and similarly mydriatics have been used as antidotes to miotics. Such reasoning is not, however, necessarily logical. The *extract* (p. 279) and *tincture* (p. 231) of physostigma are official.

Dose.—100 milligrammes (1½ grains).

STAPHISAGRIA—Staphisagria

(**Staphisag.**—Stavesacre)

The ripe seeds of *Delphinium Staphisagria* Linné (Fam. *Ranunculaceæ*), without the presence or admixture of more than 2 per cent. of foreign vegetable matter.

Constituents.—*Delphinine*, *delphinoidine*, *staphisagrin*, the latter a mixture.

Remarks.—Staphisagria is the pharmacopœial name for the seeds of *Delphinium Staphisagria*, a plant closely related to the garden larkspur, *Delphinium consolida*. The former plant has odd-shaped flowers resembling the larkspur. Stavesacre, as the official drug is called, is a very potent remedy, and is used chiefly as a wash for body-lice.

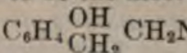
Medical Properties.—When used internally it acts something like aconite. Rarely employed, however, except externally (see above). The *fluidextract* (p. 244) is official.

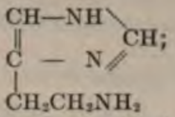
Dose.—60 milligrammes (1 grain).

ERGOTA—Ergot

(**Ergot.**—Secale Cornutum, P. I.—Ergot of Rye—Spurred Rye)

The carefully dried sclerotium of *Claviceps purpurea* (Fries) Tulasne (Fam. *Hypocreaceæ*), replacing the grain of rye, *Secale cereale* Linné (Fam. *Gramineæ*), without the presence or admixture of more than 5 per cent. of seeds, fruits and other foreign matter. Before storing, dry Ergot at a temperature not exceeding 70°C., and preserve it, protected from light, in tightly closed containers to which a few drops of chloroform or carbon tetrachloride are added from time to time to prevent attacks by insects.

Constituents.—Ergotinine, $C_{35}H_{39}O_5N_5$; *ergotoxine,* $C_{35}H_{41}O_6N_5$, the hydroxide of ergotinine, claimed to be the most active principle of ergot; para-hydroxyphenylethylamine,  $C_6H_4\begin{smallmatrix}OH\\CH_2\end{smallmatrix}CH_2NH_2$; beta-iminazolyl ethylamine



clavin (a mixture of leucin, isoleucin and valine); ergotinic acid; fixed oil, coloring matter, etc,

Few drugs have been subject to more investigation than has ergot and as a result a vast amount of confusion has existed concerning its constituents. The researches of Barger and his co-workers has largely cleared the confusion although the structure of the two characteristic alkaloids is yet to be explained. The names, ecbolin, ergotin, cornutin, sphæcelotoxin, sphæcelic acid, etc., are now obsolete, since each of these substances are now known to be impure forms of other constituents cited above.

Remarks.—Ergot is a very important drug, whose official definition requires explanation, and this means a discussion of the life-history of an interesting representative of the non-flowering plants or cryptogams. Referring to the official definition, we find that ergot is "the sclerotium of *Claviceps purpurea,* . . . replacing the grain of rye, *Secale cereale.*" As to "the grain of rye," that plant is a cultivated grass, used for food, similar to wheat or rice, and its fruit, a long cluster of oval grains, each protected by a chaffy cover, is familiar to most of us. Each grain was, in its early stage, a tender ovary, filled with soft and nutritious tissue. At this stage of growth it is apt to be attacked by the spores of the fungoid plant, *Claviceps purpurea;* the spores of non-flowering plants answering to the seed of flowering plants, an official example of which is lycopodium (noted on p. 664). These spores of *Claviceps purpurea* float through the air, seeking a location where they can obtain nourishment with as little work as possible; for the plant, *Claviceps purpurea,* is one of the "tramps" of botany—a parasite which does not work into food the materials obtained from the earth and air (as do all "good" plants), but which lazily fastens its roots into soft tissue of some living and thrifty plant and sucks from the latter, nutriment stored up for personal use.

In this manner the spores of *Claviceps purpurea* light upon the tender ovaries of the young rye, *Secale cereale.* As seed planted in goodly ground begins to sprout, so do the spores of ergot sprout when they drop upon the rye. The rootlets of each spore penetrate into an ovary of the rye from which they suck nutriment and increase in size, at the expense of their host, until eventually, from what was originally a minute fungus growth (called the mycelium), the ergot, literally eating the ovary of the rye "out of house and home," develops into a brown purple fusiform growth larger than the remaining rye grains, called, by reason of its hardness, the sclerotium. This sclerotium constitutes the official drug—ergot. A word as to the future growth of the sclerotium, which is a provision of nature for the preservation of the fungus over winter. It reaches full growth in early fall and drops to the earth, where, owing to its color, it is apt to lie unnoticed over winter—apparently a dead thing. But the warmth and sunshine of spring awakens the spark of life and it then puts forth the fruit head in which are formed the spores, which are again wafted into the air to begin once more the history of another year's havoc of the rye.

Ergot is a potent remedy of inestimable value in checking hemorrhage and in childbirth. The rye mixed with ergot is of course dangerous, and on several occasions entire communities have been poisoned by eating bread made from rye flour containing ergot.

Medical Properties.—Used as an ecbolic, producing contraction of the uterus, and for hemorrhages. Official preparations; *fluidextract* (p. 245), and *extract* (p. 275).

Dose.—2 grammes (30 grains).

OPIUM—Opium

The air-dried, milky exudation obtained by incising the unripe capsules of *Papaver somniferum* Linné and its variety *album* De Candolle (Fam. *Papaveraceæ*), and yielding, in its normal, moist condition, not less than 9.5 per cent. of anhydrous morphine.

OPII PULVIS—Powdered Opium

(**Opii Pulv.**—Opii pulvis, P. I.)

Opium dried at a temperature not exceeding 70°C., reduced to a very fine powder, and yielding not less than 10 per cent. nor more than 10.5 per cent. of anhydrous morphine. Powdered Opium of a higher morphine percentage may be brought within the required limits by admixture with powdered opium of a lower percentage, or with some inert diluent. Preserve it in well-closed containers.

OPIUM GRANULATUM—Granulated Opium

(**Opium Gran.**)

Opium dried at a temperature not exceeding 70°C. reduced to a coarse (No. 8 to No. 20) powder and yielding not less than 10 per cent. nor more than 10.5 per cent. of anhydrous morphine. Granulated Opium of a higher morphine percentage may be brought within the required limits by admixture with granulated opium of a lower percentage, or with some inert diluent. Preserve it in well-closed containers.

Constituents.—*Morphine, codeine, narceine, narcotine,* and many other alkaloids, meconic and lactic acids, gum, etc. No starch.

Remarks.—Read carefully the pharmacopœial definition given above, and note that opium is "the air-dried milky exudation" obtained by cutting—"incising"—the unripe capsules of *Papaver somniferum.* The poppy capsules (or heads) found in drugs stores are from the same plant, but are collected on ripening, when they do not contain so much milk juice.

An analogous case is found in the fig, which abounds in milk juice when green and has scarcely any when ripe.

Papaver somniferum can grow as well in this country as it can in Asia Minor, and the only reason why opium is not produced here is because the incising of the capsule (slitting with a sharp knife without penetrating the capsule) is a laborious task performed by hand, and in such work America cannot compete with the cheap labor of the East. Note that the three official forms of opium given above the *moist gum,* containing not less than 9.5 per cent. of morphine, the *powdered,* and the *granulated,* prepared by driving off the moisture from the gum and converting the dried mass either to powder or to granules, the latter made by moistening with alcohol and rubbing through a coarse sieve.

Both the powdered and the granulated must contain not less than 10 per cent. nor more than 10.5 per cent. of crystallized morphine.

Medical Properties.—Sedative and narcotic. Poisonous. *Antidote* stimulants (caffeine or coffee), electric shocks, flagellation. Above all, keep patient in motion. Official preparations: From the *moist gum* we make the *powdered* and the *granulated* and the *extract* (p. 279); from the *powdered* we make *deodorized opium* (see below), the *camphorated tincture* (p. 230), and *powder of ipecac* and *opium* (p. 293); from the *granulated* we make the *tincture* (p. 230) and the *deodorized tincture* (p. 231).

Dose.—Of all forms, 60 milligrammes (1 grain).

OPIUM DEODORATUM—Deodorized Opium

(Opium Deod.)

Deodorized Opium yields not less than 10 per cent. nor more than 10.5 per cent. of anhydrous morphine. Deodorized Opium of a higher morphine percentage may be brought within the required limits by admixture with deodorized opium of a lower percentage or with some inert diluent. Preserve it in well-closed containers.

Condensed Recipe.

Macerate 500 Gm. powdered opium with purified petroleum benzin for twenty-four hours; and then decant the benzin; macerate a second time with benzin and then decant; finally percolate the residue in a closely covered funnel until the percolate is colorless; then dry the remaining opium in the open air and finally mix with enough sugar of milk to make 500 Gm. For details see U.S.P., p. 307.

Remarks.—Deodorized (or *denarcotized*) *opium* is prepared by extracting powdered opium with benzin, that solvent removing little from the drug but its heavy narcotic odor and narcotine, an alkaloid to which many of the unpleasant after-effects of opium are said to be due. In the pharmacopœia of 1890 ether was used as the deodorizing solvent, but it has been found that benzin will do the work as thoroughly and more cheaply.

Medical Properties.—Similar to the powdered.

Dose.—60 milligrammes (1 grain).

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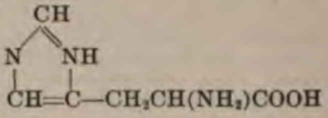
CHAPTER LI

THE PROTEINS

The proteins, or albuminoids represent a group of complex organic substances, containing hydrogen, oxygen, nitrogen, and sulphur. The chemistry of these bodies is so complex that very little is known of their exact composition. Different proteids, however, possess different proportions of the elements above mentioned, and vary in constitution from simpler bodies, like protamine, to very complex substances, which can be split into many different chemicals.

All proteins seem based upon the urea molecule, to which is attached a number of other bodies. Among these bodies, constituting part of the protein molecule, may be mentioned sulphurated compounds, carbohydrate derivatives, like levulinic acid, phosphoric acid, and notably a series of amino acids such as glycocoll (p. 604); valine (p. 618), leucine $(CH_3)_2CH-CH_2CH(NH_2)COOH$, tyrosine, $HO-C_6H_4CH_2CH(NH_2)COOH$ and histidine,



The following classification of proteins is that adopted in 1907 by the Joint Committee of Chemical and Physiological Societies:

Protamines.—Simplest form of albumin. Example, salmine $(C_{30}H_{57}N_{17}O_6)$, found in salmon spawn.

Histones.—More complex bodies isolated from blood-corpuscles. Precipitated by ammonia.

Albumins.—Soluble in water, diluted acids, alkalis, saturated solution of sodium chloride. Coagulated by heat. Contain glycocoll. Examples, serum-albumin, egg-albumin, milk-albumin, and the albumin of seeds.

Globulins.—Insoluble in water, soluble in dilute solution of sodium chloride. Coagulate on boiling. Do not contain glycocoll. Examples, myosin (from lean meat), fibrinogen (the blood constituent that clots), serum globulin, and vegetable globulins.

Scleroproteins.—Like keratin and gelatin.

Phosphoproteins, like vitellin (from yolk of egg) and caseinogen.

Conjugated Proteins.—

Nucleoproteins.—Such as are isolated from yeast-cells.

Glucoproteins.—Insoluble in water, soluble in 60 per cent. alcohol. Example, mucin.

Chromoproteins.—Like hemoglobin.

PROTEIN DERIVATIVES.—

Metaproteins.—Insoluble in water, soluble in acids and alkalis. Example, syntonin.

Proteoses.—Partly soluble in water. Products of digestion of albumin with vegetable enzymes like papain. Found in many seeds.

Peptones.—Perfectly soluble in water. Not precipitated by sodium chloride.

Polypeptides.—Mostly synthetic substances; some products of hydrolysis of proteins.

Serum-albumin is of particular interest to us inasmuch as, in the derangement of the human system producing the complaint called Bright's disease, the serum-albumin of the blood passes through the diseased kidney tissue and appears in the urine. The significance of the presence of albumin in the urine is beyond the limits of this book, and for further particulars on this interesting and important subject the reader is referred to standard works on urinary analysis such as Hawk's Physiological Chemistry.

Egg-albumin is of interest as an important food-stuff. While ordinary egg-albumen is difficult to crystallize, its crystallization has been accomplished by Hopkins. Egg-albumin combines with iron salts to form iron albuminate, which dissolves in dilute alkali. The soluble (scale) form of this chemical is made with sodium citrate.

Solution of albuminate of iron (N.F.) is prepared by treating fresh egg-albumin with solution of ferric oxychloride and then adding sodium citrate, aromatic elixir, alcohol and water.

Coagulated egg-albumin, digested with pepsin and acid, dissolves with the formation of *peptone*, which has the same percentage composition as pepsin. This is a basis of the United States Pharmacopœia test for the presence of pepsin (p. 846). Most commercial peptones are made from lean beef instead of from eggs. Peptone, like egg-albumin, forms a soluble iron salt—iron peptonate.

Solution of peptonate of iron (N.F.) is prepared by peptonizing fresh egg-albumin treating the peptone thus produced with solution of ferric oxychloride; after which sodium citrate, flavors (vanillin, acetic ether and oil of orange dissolved in alcohol) syrup glycerin and water are added.

Solution of peptonate of iron and manganese (N.F.) is made in similar fashion except that soluble manganese citrate is added along with the sodium citrate.

Phytoalbumin is of pharmaceutic interest merely because it makes up the larger bulk of horny seeds—an official example being the albumin of nux vomica.

Globulin is of passing interest because one form of it is a constituent of albuminous urine, and differs from serum-albumin by being precipitated by magnesium sulphate.

Fibrinogen is an albuminoid of the blood, the clotting of which is caused by the conversion of the substance into fibrin.

Vitellin is the albuminoid found in yolk of egg.

Syntonin is acid albumin, and can be made by boiling egg-albumen with nitric acid. It is here mentioned because its formation often misleads the tyro in urinary analysis in the nitric acid test. If nitric acid be added to urine containing albumin, the latter coagulates and precipitates. If too much acid is added, syntonin is formed, and no precipitation occurs.

Legumin is found in the seed of the Leguminosæ. It is soluble in diluted alkali.

Casein is the chief albuminoid of milk, from which it can be separated by means of rennet, acids, and some salts, such as the alums.

Nuclein is the albuminoid of the cell nucleus, that center of activity of the living cell.

Hemaglobin is an iron-bearing constituent of the blood, to which it transmits its red color. By treating defibrinated blood with acidulated pepsin and exactly neutralizing with sodium carbonate there is precipitated, *Hematin,* which has been recommended as a remedy for anemia, since it contains iron in easily assimilable form. Its crystalline hydrochloric acid compound is called *hemin.* This is closely related to ætrophyllin, a chlorophyll derivative. (See p. 782.)

Enzymes are complex bodies presumably protein derivatives although some investigators claim that their protein properties are due to admixed impurities. Because of their colloidal character, the separation of the pure enzyme is well-nigh impossible and as Czapek says "we know enzymes only by their actions." From this standpoint, we may regard enzymes as insoluble colloids, which are energetically adsorbed (p. 135) by such agents as infusorial earth, kaolin or even by filter paper. They are regarded as "the catalytic agents of the living cells" and are found both in animal and in vegetable tissue. Czapek classifies them according to their action as follows:

I. *Hydrolyzing enzymes* (Hydrolases).
  (*a*) Hydrolyse carbohydrates. Examples, invertase, diastase, maltase, lactase, amylase, pectase, etc.
  (*b*) Hydrolyze glucosides. Examples, emulsin, myrosin, etc.
  (*c*) Hydrolyse fats (lipases).
  (*d*) Hydrolyse proteins. (Proteolytic enzymes or proteases). Examples, pepsin, trypsin, etc.
II. *Enzymes, splitting off CO_2 from bodies without addition of oxygen.*
  (*a*) Those acting on hexoses. Example, zymase, found in yeast.
  (*b*) Those acting on amino-bodies. Example, urease.
III. *Oxydases.* Some of these oxidize alcohols and aldehydes to acids (such as the enzymes in mother of vinegar) while many of them oxidize phenols and other plant substances. (See p. 601.)
IV. *Reducing enzymes.*
V. *Lactic acid enzymes.*

Most enzymes are rendered inactive at 60°C. and all are destroyed when heated to 100°C. Alcohol usually lessens enzyme action; while acids frequently increase their activity. Some enzymes exert a synthetic action as is shown in the synthesis of arbutin (p. 648).

Toxins are bodies, presumably proteins, that resemble enzymes in many ways. They are adsorbed even as are enzymes and have their activity lessened by those agents affecting enzyme action. As described later, the bacteria of disease supply to the blood distinctive toxins which are intensely poisonous and which transmit to the victim the symptoms characterizing the disease.

In addition to these disease toxins, phytotoxins (*toxalbumins*) or similar bodies of vegetable origin are known. Among these may be cited *ricin,* the toxin of the castor oil bean; *abrin,* from jequirity seed; *animirtin* or the toad stool toxin; and the aspergillus or mould toxin, which is supposed to cause pellagra. It is also claimed that hay fever is due to certain pollen toxins. These toxins agglutinate the blood, a reaction employed in certain forms of disease diagnosis. The antidotes for them are called antitoxins and the success of such antitoxins in combatting diphtheria, tetanus and other diseases are described on a later page. The hay fever sera (*pollantin*, etc.) are based upon the same idea.

GELATINUM—Gelatin

(Gelat.)

The purified product obtained from animal tissues, as skin, ligaments, and bones, by treatment with boiling water.

Summarized Description.

Amorphous solid in sheets or flakes or in ground or shredded form; colorless or slightly yellow; slight characteristic odor or taste; stable in air when dry, decomposes when moist; insoluble in cold water, but softens with 5 to 10 parts of that fluid; soluble in hot water, acetic acid or glycerin; insoluble in alcohol, chloroform, ether, benzene, carbon disulphide or in fixed or volatile oils; a hot solution (1 in 40) forms a jelly on cooling. For details see U.S.P., p. 200.

For *tests for identity* and for *impurities:* Sulphur dioxide (oxidation to sulphuric acid and then precipitation with barium chloride). Heavy metals and arsenic (usual tests) see U.S.P., p. 200 and also Part V of this book.

Remarks.—Gelatin is a mixture of a large number of nitrogenous substances, such as glycocoll, alanine, leucine, glutannic acid, histidine, etc. It is prepared by boiling bones in water under pressure (as in a boiler), skimming the solution of gelatin to remove fat, and clarifying if necessary. On cooling the gelatin solidifies, and this is cut into cakes and dried on fish-nets. This explains the netted marking on the best quality of the sheet gelatin.

Glue is an impure gelatin made by digesting all kinds of gelatinous animal refuse—hide, horns, hoofs, as well as bones—by the process just given.

Gelatin is not soluble in cold water, but swells therein to form a jelly in which there is a net-work of protein molecules enclosing the absorbed liquid. It dissolves in boiling water, and is not precipitated from this solution by nitric acid nor by potassium ferrocyanide, as is egg-albumen. The precipitate formed when its solution is treated with tannin is similar to leather (p. 716). Its jelly is made impervious to moisture by treatment with potassium dichromate. Formaldehyde acts in the same way, and these two chemicals are now used for tanning finer grades of leather. The present pharmacopœia directs that gelatin contain no more than $^{2}/_{1000}$ of 1 per cent. of sulphur dioxide and that gelatin capsules contain no more than $^{15}/_{100}$ of 1 per cent. of that bleaching agent. The official test consists in treating the gelatin with phosphoric acid and sodium bicarbonate, distilling the sulphur dioxide into tenth-normal iodine V.S. (which oxidizes the H_2SO_3 into H_2SO_4) and then precipitating the resulting sulphate with barium chloride.

GELATINUM GLYCERINATUM—Glycerinated Gelatin

(Gelat. Glycerin.)

Condensed Recipe.

Soak 100 Gm. gelatin in water; drain off the surplus water; add 100 Gm. glycerin and heat on a water-bath until the gelatin is dissolved. Strain and then heat until mixture weighs 200 Gm. For details see U.S.P., p. 200.

Remarks.—The faintly straw-colored transparent jelly thus produced is used as a suppository base (p. 324), although, from what has been said about concerning the formation of leather from gelatin, it is clear that this base should not be used in making tannin suppositories.

It is important that all the water be driven off in making the mass, as provided by the pharmacopœia, for if any remains, the mass grows mouldy and turns dark brown.

PEPSINUM—Pepsin

(Pepsin.)

A mixture containing a proteolytic ferment or enzyme, obtained from the glandular layer of the fresh stomach of the hog (*Sus scrofa*, var. *domesticus* Gray) (Fam. *Suidæ*). It digests not less than 3000 times its own weight of freshly coagulated and disintegrated egg-albumen. Pepsin of a higher digestive power may be brought to this standard by admixture with pepsin of a lower digestive strength or sugar of milk. Preserve it in well-closed containers.

Summarized Description.

Lustrous, white or pale yellow, transparent or translucent scales, or grains, or spongy masses, or white or cream-colored amorphous powder; free from offensive odor; only slightly hygroscopic; forms an opalescent solution with about 50 parts of water; almost insoluble in alcohol, chloroform or ether; incompatible with alkalies, alkaline earths or alkali carbonates; inactive in solutions containing more than 0.5 per cent. of hydrochloric acid. For details see U.S.P., p. 313.

Outline of Assay.—One-tenth gramme of pepsin is dissolved in $n/12$ hydrochloric acid. Place 10 Gm. hard-boiled, sifted white of egg in a suitable bottle, disintegrate the egg-albumen by stirring with $n/12$ hydrochloric acid (35 mils in all) then add 5 mils of the pepsin solution and macerate mixture on a water-bath at 52°C. for two and one-half hours inverting the bottle every ten minutes. Then transfer the mixture to a graduated measure, washing the digestion flask with enough distilled water to make the total fluid measure 50 mils. The undissolved albumin should not measure more than 1 mil. For details see U.S.P., p. 313.

Extraction.—The mucous membrane of the hog's stomach is treated with water acidulated with hydrochloric acid at a temperature of 38° to 45°C. until the entire mass is fluid, chloroform or sulphurous acid being used to prevent putrefaction, and the liquid allowed to stand over night, whereupon the fluid portion is strained from the sediment, evaporated in vacuo to the consistence of a syrup, which is scaled on plates of glass.

In order to free it from peptone, pepsin is sometimes precipitated from the acidulated solution by saturating the latter with sodium sulphate, redissolving the precipitate in diluted acid and finally separating the sodium sulphate from the pepsin by dialysis.

Remarks.—While absolutely pure pepsin is not known, it is supposed to be a protein compound. The commercial pepsin, even of the highest strength, contains foreign matter, such as mucus, peptones, and syntonin.

It is rendered inert or is decomposed by alkalies (including sodium bicarbonate) and by bismuth subcarbonate and subnitrate. Pepsin and pancreatin should not be prescribed together as mentioned on p. 847. Whether alcohol markedly affects its action is a matter of controversy.

The pharmacopœial assay directs that 10 Gm. egg albumin be digested by 5 mils of solution of pepsin containing 0.1 Gm. in 150 mils. This means that the ten grammes of albumin are dissolved by $^{5}/_{150}$ of 0.1 Gm. pepsin; that 30 Gm. albumin will be dissolved by $^{30}/_{10} \times {}^{5}/_{150} \times 0.1$ Gm. pepsin; and that 3000 Gm. albumin will be dissolved by $^{3000}/_{10} \times {}^{5}/_{150} \times 0.1$ Gm. pepsin. Cancellation of the fractions just given will show that 3000 Gm. albumin are digested by 1 Gm. pepsin and such a pepsin is designated as 1 to 3000. Pepsins of weaker strength are known (such as 1 : 1000 and 1:500), in each case the larger number representing the number of grains of albumin which one grain of the pepsin can dissolve. These weaker pepsins can be used in place of the 1:3000 pepsin, provided a proportionally larger quantity is employed, the proportion needed being inversely the amount of egg-albumen which their pepsin dissolves. Thus, if we used 1:1800, pepsin in place of 1:3000 pepsin, for every 1800 grains of pepsin of 1:3000 strength, we will require 3000 grains of the 1:1800. It can be seen from this statement that such problems are solved by alligation, the method being exactly identical with the reduction of alcohol of a certain strength to that of another strength.

Pepsin is a valuble aid to digestion. While there are no preparations of pepsin recognized in the pharmacopœia, the National Formulary gives recipes for *saccharated pepsin* (pepsin 10 per cent., sugar of milk. 90 per cent.) *solution of pepsin, aromatic solution of pepsin* and *antiseptic solution of pepsin.* (See p. 191.) That popular preparation, *compound digestive elixir,* was dropped in the last revision of the Formulary, although several types of pepsin elixirs are recognized. (See p. 209.)

Dose.—500 milligrammes (8 grains).

PANCREATINUM—Pancreatin

(Pancreat.)

It contains enzymes, consisting principally of amylopsin, trypsin and steapsin, naturally existing in the pancreas of warm-blooded animals and obtained from the fresh pancreas of the hog (*Sus scrofa* var. *domesticus* Gray) (Fam. *Suidæ*), or of the ox (*Bos taurus* Linné) (Fam. *Bovidæ*). It converts not less than 25 times its own weight of starch into soluble carbohydrates. Pancreatin of a higher digestive power may be brought to this standard by admixture with sugar of milk. Preserve it in well-closed containers.

Summarized Description.

Cream-colored amorphous powder; faint but not offensive odor; slowly and completely soluble in water; insoluble in alcohol; converts proteins into proteoses and starch in dextrins and sugars; active in faintly alkaline media; strongly acid or alkaline solutions are inert.

For *tests for identity* and for *impurities:*

Fats (etheral extract on evaporation yields not more than 30 per cent. of residue) see U.S.P., p. 309.

Outline of Assay.—Carefully wash potato starch; make the equivalent of 7.5 Gm. of the dried starch into a mucilage by boiling with water. To this paste after cooling, is added 0.3 Gm. pancreatin dissolved in 10 mils of distilled water. Keep the mixture at 40°C. for five minutes when all of the starch should be hydrolyzed as evidenced by the fact that a sample of the digested paste does not color diluted iodine solution blue, red or violet. For details see U.S.P., p. 309.

Composition.—The enzymes, amylopsin, myopsin, trypsin, and *steapsin.* Trypsin and myopsin digest albumin, amylopsin hydrolyzes starch, while steapsin emulsifies fats.

Extraction.—The minced pancreas is macerated for some time with water containing enough chloroform to prevent putrefaction. The liquid is then expressed from the residue, is filtered, and rapidly evaporated at a temperature not exceeding 45°C.

Remarks.—The test for pancreatin is the estimation of its peptonizing power; that is, 0.28 gramme of pancreatin and 1.5 grammes of sodium bicarbonate should be capable of converting the albumin of 400 mils cows' milk into peptone, which is not coagulated by acetic acid. Not only is this process used as a test, but the *peptonized milk* itself is sometimes used as a diet where the stomach cannot tolerate the natural albumin of milk.

The assay of pancreatin is based on its ability to convert starch into dextrin and maltose; the requirements being that one part of pancreatin should be able to transform at least 25 times its weight of starch.

While pepsin acts as in acid medium, pancreatin is of value only when combined with mild alkalies, and this emphasizes the absurdity of prescribing these two substances in combination, a medium which will develop the activity of pepsin rendering pancreatin inert.

Pepsin and pancreatin are of value in dyspepsia, both acting as food digestants; their natural function in the animal economy. The two differ, however, as to the kind of food each digests, pepsin digesting albuminoid matter in the stomach, while pancreatin digests albuminoids, starch, and fat in the intestines. To be effective, pancreatin should be administered only in enteric pills. It is a constituent of peptonizing power N.F. (p. 294) and *pancreatic solution* N.F. (p. 191).

Dose.—500 milligrammes (8 grains).

DIASTASUM—Diastase

A mixture containing amylolytic enzymes obtained from an infusion of malt. It converts not less than 50 times its weight of potato starch into sugars. Preserve it in well-closed containers, protected from light, heat and moisture.

Summarized Description.

Yellowish-white, odorless and tasteless, amorphous powder or translucent scales; soluble in water; almost insoluble in alcohol; its ability to hydrolyzed starch is lessened by age and by the presence of acids or alkalies and is destroyed by heat or by strong acids. For details see U.S.P., p. 131.

Outline of Assay.—Like that for pancreatin, the equivalent of 5 Gm. dry starch being digested by 0.1 Gm. diastase, see U.S.P.

Remarks.—Diastase is the mixture of enzymes, obtained by macerating malt with cold water, and then pouring the filtered infusion into double the amount of strong alcohol. Taka diastase is prepared by treating wheat bran with a peculiar fungus, called in Japan "moyashi," extracting the diastase thus formed with water, and precipitating with alcohol. Diastase converts starch into dextrin and maltose, and is, therefore, used in starchy indigestion.

Dose.—500 milligrammes (8 grains).

Papain is the enzyme obtained from the milk juice of *Carica papaya*, and has been recommended as a general digestant and for dissolving the diphtheritic membrane. Do not confuse this with a liquid nostrum, *papaine*, which is used as a sedative.

Emulsin and *myrosin* are enzymes found respectively in bitter almond and black mustard, and have already been considered under those headings. Of their chemistry but little is known.

Flesh is a combination of fibrous tissue with blood, albuminoids, and a host of other substances, such as the urea derivatives, sarcin and carnin.

Meat preparations used for invalid diet are a part of the stock of the modern drug-store, hence a few words concerning these are in place. Of these meat products the only ones of real nutritive value are *meat-juices*, made by expressing the juice from a slightly broiled steak. These juices decompose as rapidly as does meat itself, hence must be either fortified by preservatives or dispensed in a perfectly fresh condition. The writer knows of several progressive pharmacists who have built up a large trade in meat-juice, preparing same fresh every day.

Beef-tea is made by digesting finely chopped meat with warm water and straining.

Beef-extracts represent beef-tea evaporated in vacuo—being administered redissolved in warm water. Both of these products are practically devoid of nutritive qualities, its stimulating action being due to the sarcin and carnin they contain, these bodies acting similarly to their allied body, caffeine. One authority has claimed that "beef-tea" has little more nutritive action than has urine.

Milk is caseine emulsion of fat (butter), containing milk-sugar and inorganic salts.

When milk is treated with yeast, the milk-sugar ferments to lactic acid, and if the operation is carefully conducted, we obtain the pharmaceutical called *koumiss*. A recipe for this liquor is found in the National Formulary under the name of "*lac fermentatum*."

The original koumiss was made in Russia by fermenting mares' milk with a peculiar ferment, kephir.

Condensed milk is milk evaporated in vacuo, and usually preserved by addition of cane-sugar.

Solid evaporated milk is now on the market; one brand—"Nutrium" —consists of 40 per cent. proteids, 45.7 per cent. sugar of milk, 8.57 per cent. lime salts and other minerals, and 5.73 moisture. These powders are made by spraying the milk into a heated revolving cylindrical dryer. It is said that 100 pounds skim milk give 10 pounds nutrium.

Infant's food, of which there are a great host, can be grouped into the following classes:

Milk Foods.—Such as condensed milk. Bad as exclusive infant diet.

Predigested Foods.—Milk foods digested with pepsin or pancreatin.

Cereal Foods.—Grains dextrinized by heat. To be used mixed with milk.

Malted Foods.—Cereals digested with milk and then dried. Used mixed with milk.

Mixed Foods.—(*a*) Combinations of extract of barley or wheat with powdered predigested milk.

(*b*) Dextrinized cereals with unpredigested milk powder.

ANIMAL DRUGS

At this place we will discuss those drugs of animal origin—whole animals, animal organs, and animal excretions—which are of such complex composition that they cannot be classed among definite chemicals. As examples of animal products that are definite chemicals may be cited *lactic acid* (p. 609), the animal *fats*, *oils*, and *waxes* discussed in Chapter XLI, and the animal proteins, *pepsin* and *pancreatin*, discussed on the foregoing pages of this chapter. The discussion of the other animal products in this chapter may be misleading, inasmuch as some of the products here considered are not albuminoidal in character. However, as the characteristic compounds of most living animal tissue are protein matter, it seems appropriate to discuss animal drugs at this place, with the warning given above.

The drugs to be considered may be classified as follows:

Whole Animals.—Cantharides, U.S.P., and Cochineal, U.S.P.

Animal Organs.—Egg (or the yolk, Vitellus, U.S.P. 1890), isinglass, U.S.P. 1890, the musk-sac (the contents thereof is official), thyroidal glands, U.S.P., suprarenal glands, U.S.P.; pituitary body, U.S.P.

Animal Excretions.—Oxgall, U.S.P.; milk (see above).

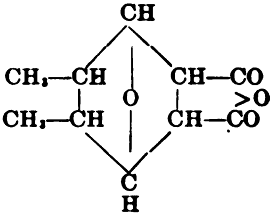
Antitoxins.—Antidiphtheritic serum, U.S.P.; antitetanic serum, U.S.P.; other serums: vaccine virus, U.S.P.

CANTHARIS—Cantharides

(**Canthar.**—Spanish Flies—Russian Flies)

The dried beetle, *Cantharis vesicatoria* (Linné) De Geer (Fam. *Meloideæ*, Order *Coleoptera*), yielding not less than 0.6 per cent. of cantharidin. Preserve Cantharides in tightly closed containers, adding a few drops of chloroform or carbon tetrachloride, from time to time, to prevent attack by insects.

Constituents.—*Cantharidin*, $C_{10}H_{12}O_4$, wax, fat, etc. Cantharidin, the vesicating principle, is the anhydride of cantharidinic acid. Gadamer thinks that its graphic formula is



It is a neutral principle and might therefore be discussed more properly in Chapter XLVIII.

Remarks.—Cantharides are beetles, which differ from flies in having cases into which they fold their wings. The active principle is cantharidin, which produces the irritating effects of the drug, and which is sublimable. Hence care must be observed in hovering over melting cantharides cerate, as thereby severe irritation of the eyes may ensue.

Medical Properties.—Aphrodisiac, vesicant, stimulant to scalp. Administered internally (rarely nowadays) in the form of the official *tincture* (p. 225). Externally as the official *cerate* (p. 328) properly spread as the official *plaster* (p. 341). The pharmacopœia also gives a recipe for *cantharidal collodion* (p. 213).

COCCUS—Cochineal

The dried female of the insect *Coccus Cacti* (Fam. *Coccidæ*) enclosing the young larvæ.

Constituents.—*Carminic acid*, wax, and fat; not more than 6 per cent. ash.

Remarks.—Cochineal is the female insect gathered while with young. Carminic acid, $C_{22}H_{22}O_{13}$, is discussed among the coloring principles on p. 783. *Carmine* is the insoluble form of carminic acid, made by precipitating an infusion of cochineal with either alum or potassium bitartrate. The ash requirement of the Pharmacopœa (not more than 6 per cent.) is based on the fact that cochineal is largely adulterated with mineral matter.

Medical Properties.—Used entirely as a color. For this purpose, however, *solution of carmine*, N.F. (p. 190) and *cochineal color*, N.F. (p. 190) are usually employed.

Ovi Vitellum Recens (U.S.P. 1890; N.F. IV), or *yolk of egg*, contains 50 per cent. of fixed oil emulsionized by proteins (vitellin, livitin, etc.). The yolk contains about 12 per cent. of lecithin (p. 670) and a yellow coloring matter called ovochromin. It is used as a protective dressing and for making emulsion of cod-liver oil (p. 261).

Ichthyocolla (U.S.P. 1890), or *isinglass*, represents the dried "sounds" (swimming bladders) of the Russian sturgeon, *Acipenser Huso*, whose eggs (roe) constitute that delicacy, caviar. It is almost pure gelatin, and is the adhesive constituent of court plater. (*Emplastrum Ichthyocollæ*, U.S.P. 1890).

MOSCHUS—Musk

(Mosch.—Tonquin Musk—Deer Musk)

The dried secretion from the preputial follicles of *Moschus moschiferus* Linné (Fam. *Moschidæ*). Preserve it carefully in glass-stoppered bottles.

Constituents.—Ammonia, cholesterin (p. 670), fat, wax, odorous principle.

Remarks.—By "preputial follicles" is meant a little sac situated between the navel and the penis of the musk deer (*Moschus moschiferus*), an animal that lives in the mountains of Central Asia. Official musk is the "secretion"—the contents—of this sac. It is used largely in perfumery. Bear in mind that artificial musk (p. 736) has nothing in common with the drug, save its similar perfume.

Medical Properties.—Powerful stimulant, of especial value in the exhaustion that comes with pneumonia. While little used, it is badly needed when desired, and that of the best quality; hence the pharmacist should always be ready to furnish a high grade of musk on demand. The tincture (p. 229) is official.

Dose.—250 milligrammes (4 grains).

THYROIDEUM SICCUM—Dried Thyroids

(**Thyroid. Sicc.**—Glandulæ Thyroideæ Siccæ, U.S.P. VIII—Desiccated Thyroid Glands)

The thyroid glands of animals which are used for food by man, freed from connective tissue and fat, dried and powdered, and containing not less than 0.17 per cent. nor more than 0.23 per cent. of iodine (I = 126.92) in thyroid combination. One part of Dried Thyroids corresponds to approximately 5 parts of the fresh glands.

Summarized Description.

Yellowish, amorphous powder; slight characteristic odor; must be free from iodine in inorganic form; moisture, not more than 6 per cent.; ash, not more than 5 per cent. For details see U.S.P., p. 443.

For *tests for identity* and for *assay* see U.S.P. and also Part V of this book.

Constituents.—*Thyroidin*, combined with proteid matter, etc.

Remarks.—The thyroid gland is found in the neck of man and other animals and its abnormal development represents the disease called goiter. The activity of the gland, when used as medicine, is proportional to its organic iodine content; some specimens containing one-fourth of 1 per cent.

Medical Properties.—Furnishes iodine in non-irritating and easily absorbable form. Used in goiter, obesity, etc.

Dose.—100 milligrammes (1½ grains).

SUPRARENALUM SICCUM—Dried Suprarenals

(**Supraren. Sicc.**—Glandulæ Suprarenales Siccæ U.S.P. VIII—Desiccated Suprarenal Glands

The suprarenal glands of animals which are used for food by man, cleaned, dried, freed from fat, and powdered, and containing not less than 0.4 per cent. nor more than 0.6 per cent. of epinephrine, the active principle of the suprarenal gland. One part of Dried Suprarenals represents approximately 6 parts of fresh glands, free from fat. If assayed biologically *one gramme* of Dried Suprarenals contains the equivalent of *ten milligrammes* of lævo-methylamino-ethanol-catechol.

Summarized Description.

Yellowish-brown, amorphous powder; slight characteristic odor; partially soluble in water, moisture, not more than 7 per cent.; ash, not more than 7 per cent. For details see U.S.P., p. 424.

For *tests for identity* and for *assay* see U.S.P. and also Part V of this book.

Constituents.—Epinephrin, fat, proteids, ash, etc.

Remarks.—The word "suprarenal" means "above the kidney," and explains the location of this gland in the animal body. Epinephrin is a basic body described on p. 720.

This alkaloid in a more or less pure state is now largely advertised under the names *adrenalin, suprarenin, adrin,* etc.

Medical Properties.—Increases blood-pressure, hence of value in shock. Relieves inflammation of mucous membrane, hence recommended for catarrh, hay-fever, etc.

Dose.—Of glands, 250 milligrammes (4 grains). For external use an aqueous or oily solution of the active principle (1:100,000) is preferable.

HYPOPHYSIS SICCA—Desiccated Hypophysis

(Hypophysis Sic.—Desiccated Pituitary Body)

The posterior lobe obtained from the pituitary body of cattle, cleaned, dried, and powdered.

Summarized Description.

Yellowish or grayish amorphous powder; characteristic odor; partially soluble in water. For details see U.S.P., p. 226.

Remarks.—This new official substance is the posterior lobe of the pituitary gland, which is a pale reddish body attached to the undersurface of the cerebrum. This gland not only exercises a marked influence on the brain wherein it is found but also on the entire growth of the animal. The posterior lobe contains a substance having marked influence upon the muscles of the blood-vessels and the uterus.

Medical Properties.—Used in various forms of hemorrhage.

Dose.—30 milligrammes (½ grain).

LIQUOR HYPOPHYSIS—Solution of Hypophysis

(Liq. Hypophysis—Solution of the Pituitary Body)

A solution containing the water-soluble principle or principles from the fresh posterior lobe of the pituitary body of cattle.

Condensed Recipe.

Extract the hypophysis with acidulated water, boil, filter, sterilize and seal in sterile ampuls. See U.S.P.

Summarized Description.

Almost colorless, transparent liquid; faint characteristic odor. For details see U.S.P., p. 247.

Outline of Assay.—One mil of solution diluted 20,000 times has the same activity on the uterus of a virgin guinea-pig as has a 1 to 20,000,000 solution of beta-iminazolylethylamine. See U.S.P.

Remarks.—The above description of this new official solution, when read with what has just been said about the pituitary gland, is self-explanatory.

Dose.—1 mil (15 minims).

FEL BOVIS—Oxgall

The fresh bile of the ox, *Bos taurus* Linné (Fam. *Bovidæ*).

Summarized Description.

Brown-green or dark green viscid liquid; characteristic odor; disagreeable bitter taste; sp. gr. 1.015 to 1.025; For details see U.S.P., p. 164.

Color Test.—Brown red, then carmine, then purple, then violet, when treated with sugar solution, followed by sulphuric acid. For details see U.S.P.

Constituents.—Sodium salts of *glycocholic acid* and *taurocholic acid; lecithin; cholesterin;* the bile-pigments, bilirubin, biliverdin, etc.; mucin; water, 85 per cent. The two acids above mentioned are combinations of *cholalic acid*, $C_{24}H_{40}O_5$, with glycocoll (p. 604), and with taurine (p. 604) respectively. Cholesterin is an alcohol ($C_{24}H_{45}OH$) whose chemistry is little understood. *Isocholesterin* will be remembered as the alcohol with which oleic, stearic, and palmitic acids are united in wool-fat (p. 662).

Remarks.—Bile is the secretion of the liver, and is designed to emulsionize and assimilate fats. The test given above, depending on the play of colors, when bile is treated with sugar and sulphuric acid (Pettenkofer's test), is very characteristic.

Medical Properties.—Laxative and cholagogue. Almost invariably used in the official *extract* (p. 276).

Fel Bovis Purificatum (U.S.P. VIII), or *purified oxgall*, was a form of pitular extract of oxgall. It is now replaced by the official powdered extract of oxgall (p. 276).

SERUM ANTIDIPHTHERICUM—Antidiphtheric Serum

(Ser. Antidiph.—Diphtheria Antitoxin)

A fluid, having a potency of not less than 250 antitoxic units per mil, separated from the coagulated blood of the horse, *Equus Caballus* Linné (Fam. *Equidæ*), or other large domestic animal, which has been properly immunized against diphtheria toxin. It must be kept in sealed glass containers in a dark place, at a temperature between 4.5° and 15°C.

Summarized Description.

Yellowish or yellow-brown, transparent or slightly turbid liquid sometimes with a slight sediment; odorless or with odor of antiseptic employed; loses potency on aging, must be sterile; phenol or cresol may be used as preservatives in proper specified quantities; total solids, not more than 20 per cent.; sera must not have a lower potency than 250 units per mil and must be prepared in a factory licensed by the Secretary of the Treasury of the United States; outline of the federal labelling law is given; standard of strength is that established by the United States Public Health Service.

SERUM ANTIDIPHTHERICUM PURIFICATUM—Purified Antidiphtheric Serum

(Ser. Antidiph. Purif.—Antidiphtheric Globulins—Concentrated Diphtheria Antitoxin—Diphtheric Antitoxin Globulins—Refined and Concentrated Diphtheria Antitoxin)

A solution in physiological solution of sodium chloride of certain antitoxic substances, proteins obtained from the blood serum or plasma of the horse, *Equus Caballus* Linné (Fam. *Equidæ*), or other large domestic animal, which has been properly immunized against diphtheria toxin. After the serum or plasma from the immunized animal has been collected, the antitoxin-bearing globulins are separated from the other constituents of the serum or plasma and dissolved in water, and sufficient sodium chloride is then added to make a solution containing from 0.6 to 0.9 per cent. of the salt. It has a potency of not less than 250 antitoxic units per mil. It must be kept in sealed glass containers in a dark place, at a temperature between 4.5° and 15°C.

Summarized Description.

Transparent or slightly opalescent liquid, sometimes with a slight deposit, other properties like antidiphtheric serum.

SERUM ANTIDIPHTHERICUM SICCUM—Dried Antidiphtheric Serum

(Ser. Antidiph. Sicc.—Dried Diphtheria Antitoxin)

Dried Antidiphtheric Serum is obtained by the evaporation of either Antidiphtheric Serum or Purified Antidiphtheric Serum in a vacuum, over sulphuric acid, or other desicating agent, or by passing over it a current of warm air freed from bacteria. It has the potency of not less than 4000 units per gramme. It must be kept in hermetically sealed, amber-colored glass containers free from air, at a temperature between 4.5° and 15°C., preferably in a dark place.

Summarized Description.

Orange or yellowish flakes, or small lumps, or yellowish-white, odorless powder; readily soluble in nine parts of distilled water, forming an opalescent and slightly viscous fluid; other properties like antidiphtheric serum.

SERUM ANTITETANICUM—Antitetanic Serum

(Ser. Antitetan.—Tetanus Antitoxin)

A fluid having the potency of not less than 100 units per mil, separated from the coagulated blood of the horse, *Equus Caballus* Linné (Fam. *Equidæ*), or other large domestic animal, which has been properly immunized against tetanus toxin. It must be kept in sealed glass containers in a dark place, at a temperature between 4.5° and 15°C.

Summarized Description.

Yellowish or yellow-brown transparent or slightly turbid liquid sometimes with a slight deposit; odorless or smelling like the antiseptic used; other description like that for antidiphtheric serum.

SERUM ANTITETANICUM PURIFICATUM—Purified Antitetanic Serum

(Ser. Antitetan. Purif.—Antitetanic Globulins—Concentrated Tetanus Antitoxin—Refined and Concentrated Tetanus Antitoxin—Tetanus Antitoxic Globulins)

A solution in physiological solution of sodium chloride of certain antitoxic substances obtained from the blood serum or plasma of the horse, *Equus Caballus* Linné (Fam. *Equidæ*), or other large domestic animal, which has been properly immunized against tetanus toxin. After the serum or plasma from the immunized animal has been collected, the antitoxin-bearing globulins are separated from the other constituents of the serum or plasma and dissolved in water, and sufficient sodium chloride is then added to make a solution containing from 0.6 to 0.9 per cent. of the salt. It has a potency of not less than 100 units per mil. It must be kept in sealed glass containers in a dark place, at a temperature between 4.5° and 15°C.

Summarized Description.

Transparent or slightly opalescent liquid, sometimes with a slight deposit; odorless or smelling like the antiseptic used; other description like that for antidiphtheric serum.

SERUM ANTITETANICUM SICCUM—Dried Antitetanic Serum

(Ser. Antitetan. Sicc.—Dried Tetanus Antitoxin)

Dried Antitetanic Serum is obtained by the evaporation of either Antitetanic Serum or Purified Antitetanic Serum in a vacuum, over sulphuric acid or other desiccating agent, or by passing over it a current of warm air freed from bacteria. It has a potency of not less than 1000 units per gramme. It must be kept in hermetically sealed amber-colored glass containers, free from air, at a temperature between 4.5° and 15°C. preferably in a dark place.

Summarized Description.

Orange or yellowish flakes, or small lumps or yellowish-white, odorless, powder, readily soluble in 9 parts of distilled water, forming an opalescent and slightly viscous fluid; other description like that for antidiphtheric serum.

Remarks.—The subject of antitoxins, of which the six officials outlined above are the prominent examples, is more medical than pharmaceutic, and these products can never be made by the retail pharmacist, a large well-equipped and aseptic plant being essential to their successful manufacture. Because of this fact the admission of these substances into the pharmacopœia caused much discussion and the final decision as to admitting the six now official products was based on the desire to secure a uniform standard for this important form of medication.

As to the theory of antitoxins, Behring showed that most animals when infected with certain diseases are capable of generating in their blood-serum substances (antitoxins) capable of neutralizing the poisonous matter (toxins) transmitted to the blood by the organism producing the disease; and, further, that the question as to whether the animal survives or succumbs to the disease is a question as to which predominates, the toxin or the antitoxin.

Applying this idea in the manufacture of diphtheria antitoxin, the animal (usually a horse) is inoculated with cultures of diphtheria germs, first in small doses then in large ones. A mild case of the disease is thus produced in the animal, which immediately combats the toxin by the formation of the antitoxin. As increased doses of the toxin are administered, an increased amount of antitoxin is produced until, at the end of two weeks, the animal has stored up so much antitoxin in its blood-serum that it becomes "immune."

A certain quantity of blood (5 to 10 liters) is then removed through the jugular vein, allowed to stand until the albuminoids separate by coagulation, and the liquid portion (the serum) is then mixed with some antiseptic (phenol, cresol, etc.), is standardized, and then put into glass tubes which are immediately sealed.

The pharmacopœia directs that the standards of strength expressed in units of antitoxic power—"*immunity unit*"—be that of the United States Public Health and Marine Hospital Service. Thus antidiphtheric serum U.S.P. and purified antidiphtheric serum U.S.P. must have a potency of not less than 250 antitoxic units per mil. A brief explanation of this statement is in order.

The toxin (as the culture of the germ is called) is prepared and administered to, say, a dozen guinea-pigs of the same weight (250 grammes); to each a different dose. The smallest amount killing one of the guinea-pigs within four days is "the minimum fatal dose." One hundred times this quality of toxin is mixed with various amounts of the antitoxin serum, and administered to a second batch of guinea-pigs. The smallest amount of the antitoxic serum which prevents the hundred-fold dose of toxin from being fatal to the guinea-pig represents the "immunity unit;" 100 times this volume of serum represents 100 units; 3000 times this volume represents 3000 units, and so on.

The amounts of toxin and antitoxin serum involved in guinea-pig testing is very small—$\frac{1}{200}$ mil of the toxin is apt to be fatal; while $\frac{1}{300}$ mil of the antitoxic serum often represents one "immunity unit." Hence the tests are carried out with diluted toxin and antitoxin of known strength.

The absolute strength of the same volume of different batches of serum may vary materially, hence the dosage is by "immunity units," and not by volume. Thus in one case 3000 units may be in 30 mils of serum; in another in 50 mils of serum.

Of the six sera now official, only one—*antidiphtheric serum*—was recognized by U.S.P. VIII. Of the other two forms of diphtheria antitoxin now official, *purified antidiphtheric serum* is a refinement of the original form, consisting of the antitoxin-bearing globulins precipitated from the original serum with ammonium sulphate and then dissolved by use of saturated sodium chloride solution. This purified serum has the same potency as has the original serum.

Dried antidiphtheric serum is prepared from either of those just mentioned by evaporation of the water with a minimum amount of heat. It has ten times the potency of the fluid sera just described.

Likewise the present pharmacopœia recognizes three forms of antitetanic serum; the regular *tetanus antitoxin*, the antitetanic *globulins* and *the dried antitetanic serum*. It will be noticed on reading the pharmacopœial monographs for these sera, that are summarized above, that the standard of antitoxic power of these has been fixed at 100 units per gramme for the first two and at 1000 units per gramme for the third.

Doses.—Of the antidiphtheric sera: curative, 10,000 units. Protective, 1000 units. Of the antitetanic sera: curative, 10,000 units. Protective, 1500 units.

Similar *antitoxins* for *snake-bite, bubonic plague,* and *glanders* are now on the market, and all prepared by a similar process, namely, from the serum of animals infected with the special disease for which the antitoxin is intended.

VIRUS VACCINICUM—Vaccine Virus

(**Virus Vaccin.**—Glycerinated Vaccine Virus—Smallpox Vaccine—Jennerian Vaccine)

The pustules of vaccinia or cowpox from vaccinated animals of the bovine species, removed and prepared under aseptic conditions. Preserve it at a temperature between 4.5° and 15°C., protected from light.

Condensed Recipe.

Vaccine pulp is triturated or ground, strained and made with a smooth emulsion with glycerin. See U.S.P., p. 487.

Summarized Specifications.

Vaccine virus must be prepared in a factory licensed by the Secretary of the Treasury of the United States; from animals free from disease and inspected by government veterinarians; the virus must be examined bacteriologically; must be marketed in sterile containers and must be labelled as provided for in the federal regulations.

Remarks.—Although vaccine virus has been used for many years, the present is the first United States Pharmacopœia to give it official recognition. As the official monograph outlined above shows, this vaccine is the virus from the sores upon a heifer which has been inoculated with cowpox. While antitoxins contain the principles protecting one against the poison of a disease, vaccines contain the substance that produce the disease. Thus vaccine virus gives a man the comparatively mild disease, cowpox, and the sufferer develops in his blood the cowpox antitoxin, which protects him from the ravages of small-pox.

The virus was formerly marketed as a dry coating on ivory points or on quills. Now it is almost always dispensed in glycerinic emulsion in sealed tubes.

Note that vaccine virus, as well as the antitoxins, must be kept in a cool place, and that they deteriorate with age.

Opsonins are substances which, introduced into the blood, act on disease bacteria, so changing them as to cause them to be readily absorbed by the phagocytes, those bodies found in the blood, and upon whose preservation depends the well-being of the animal. Bacteria not so treated attack the phagocytes, producing the various bacterial diseases. Each species of bacteria has its special opsonin, and these opsonins, or bacterial vaccines, can be prepared by making cultures of the special bacteria, killing them, suspending in normal saline solution, and sterilizing at 60°C. Such products are usually called bacterial vaccines.

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PART V

PHARMACEUTIC TESTING

CHAPTER LII

INTRODUCTORY

On the foregoing pages enough has been said to emphasize the importance of examining pharmaceuticals and chemicals, both as to composition and also the quantity of each component. The subject of such testing is called *analytic chemistry*, a branch of science the many details of which are clearly beyond the scope of this work. In the few chapters that follow only an outline of the principles of pharmaceutic testing as directed in the pharmacopœia will be given, and for complete details the reader is referred to one of the several books on analytic chemistry mentioned in the Preface.

Analytic chemistry is divided into two subdivisions—*qualitative analysis*, which aims to find the constituents of a compound, and *quantitative analysis*, by means of which we can estimate the quantity of each ingredient. Quantitative analysis is, in turn, divided into three classes: Gravimetric, volumetric, gasometric and colorimetric analysis.

Gravimetric analysis is where the quantity of ingredient is estimated by conversion into an insoluble compound containing a definite proportion of the ingredient, collecting and weighing the precipitate, and from the weight obtained estimating the amount of the ingredient by molecular proportions.

Volumetric analysis (or *titration*) is where the quantity of ingredient is estimated from the amount of a definite standard solution of a chemical (*volumetric solution*) required to combine with it exactly; the amount of this volumetric solution required exactly to complete the reaction is usually denoted by the change in color produced by a third chemical, called an *indicator*.

Assaying is a term applied in pharmacy to the quantitative estimation of the active ingredient of a mixed product, notably a drug. As the quantity is sometimes estimated by gravimetric analysis and sometimes by volumetric analysis, the process is merely a modification of these, the only difference being that some process of extraction must first be employed.

The *apparatus* used in pharmaceutic testing have been referred to in the chapters comprising Part I. For qualitative analysis, funnels, beakers, spritz-bottles, flasks, evaporating dishes, filter-paper, and Bunsen burners are required, and these have already been described. In addition thereto it is necessary to have test-tubes and test-tube racks (p. 145); red and blue litmus-paper (which is filter-paper dipped in a decoction of the lichen, litmus, and treated with acid to make it red, or alkali to make it blue); blue glass; and platinum wire and foil.

The chemical to be analyzed is usually made into a solution and treated with solutions of other chemicals. Such solutions are called *test solutions.* This phrase is frequently abbreviated to T.S. (example, potassium iodide T.S.).

The test solutions are usually prepared by making a 10 to 20 per cent. solution of the chemical (called *reagent*) in distilled water, but many of the test solutions must be prepared by special treatment. A recipe for each test solution directed by the pharmacopœia is found in the appendix to that standard (pp. 521–554), to which the reader is referred.

These test solutions should be kept in special bottles, closed either with glass or rubber stoppers. Such a test solution bottle is shown in Fig. 246.

While most qualitative analyses are performed with test solutions, the reagent, hydrogen sulphide, is employed as a gas and is usually generated by action of sulphuric acid on ferrous sulphide in a Kipp's generator (Fig. 247), which acts automatically. Then sometimes the reagent is employed in solid form. Thus, borax is fused for the borax bead test, sodium carbonate and potassium nitrate are melted on platinum foil in several of the fusion tests, etc.

Fig. 246.—Reagent bottle.

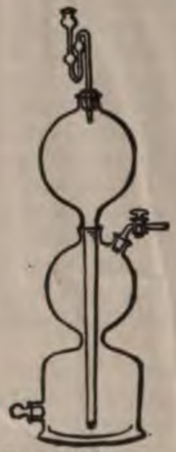

Fig. 247.—Kipp's gas generator.

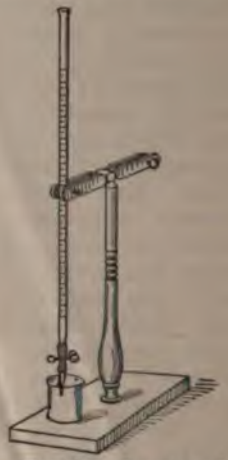

Fig. 248.—Burette and holder.

In quantitative analysis the apparatus used are crucibles, desiccators, analytic balances, measuring vessels, such as burettes (Fig. 248), pipettes, measuring cylinders, 100-mil and 1000-mil bottles. The reagents used are practically the same as in qualitative analysis, with the additional line of volumetric solutions, the manufacture of which will be discussed a few pages farther on.

In drug assays the apparatus is practically the same as that just mentioned, but in addition thereto, since the active principle is usually extracted by shaking out of the watery solution with ether or chloroform (separation from an immiscible solvent), a separatory funnel is required.

The detection of the ingredients of a compound in qualitative analysis is accomplished in several ways:

I. *By production of a characteristic precipitate:* thus a solution of a sulphate when mixed with barium chloride T.S. gives a white precipitate, insoluble in boiling nitric acid.

II. *By production of a characteristic color in a solution:* thus a diluted solution of copper sulphate gives a deep azure blue solution with excess of ammonia water.

III. *By production of a characteristic odor:* thus an acetate warmed with alcohol and sulphuric acid gives the pleasant odor of acetic ether.

IV. *By transmitting a characteristic color to a colorless Bunsen flame:* thus a trace of sodium salt on a loop of platinum wire placed in a Bunsen flame makes it a vivid yellow.

V. *By giving a characteristic color to a borax bead:* thus if borax is fused on a loop of platinum wire and a trace of a manganese salt added to the bead, which is then fused once more, the cooled solidified bead will be found to possess a beautiful amethyst color.

VI. *By giving a characteristic color to specially prepared test-paper:* thus borax gives buff-colored turmeric paper a red-brown tint.

VII. *By producing a play of colors when brought in contact with the reagent on a porcelain surface:* thus most alkaloids give characteristic color reactions when treated with a drop of sulphuric acid and a trace of potassium dichromate.

VIII. *By leaving a characteristic residue on heating on charcoal with a blow-pipe:* thus zinc salts when treated with cobaltous nitrate and heated with a blow-pipe leave a vivid green spot.

It will be noticed that the pharmacopœia makes use of all of these several means of identity, and a classification of the qualitative tests of the pharmacopœia will comprise the next chapter.

CHAPTER LIII

THE QUALITATIVE INORGANIC TESTS OF THE PHARMACOPŒIA

Free chlorine *liberates iodine from potassium iodine.*

This test is used to detect free chlorine in:
Hydrochloric Acid } For details, see U.S.P.
Diluted Hydrochloric Acid }
Benzoic Acid.—A modified silver nitrate test. See U.S.P., p. 8.

Hydrochloric acid and **chlorides** *give, with silver nitrate T.S., a white curdy precipitate insoluble in nitric acid, but soluble in ammonia water.* This precipitate is silver chloride (AgCl).

The following official chemicals are submitted to this test for chlorides. In some cases, slight modifications are directed and therefore for details the reader is referred to the appropriate monograph in the pharmacopœia.

PRESENT AS INGREDIENTS

Hydrochloric acid.
Sodium Chloride.
Ammonium Chloride.
Calcium Chloride.
Zinc Chloride.
Ferric Chloride.
Solution of Ferric Chloride.
Tincture of Ferric Chloride.
Corrosive Mercuric Chloride.
Gold and Sodium Chloride.
Ammoniated Mercury.
Pilocarpine Hydrochloride.
Quinine Hydrochloride.
Cocaine Hydrochloride.
Hydrastine Hydrochloride.
Quinine Hydrochloride.

Chlorides Sought as Impurity.—The diversified modifications of the test necessary to adopt it to the different conditions, obtaining with the several chemicals tested, make classification difficult. For this reason the reader is referred, for details, to the appropriate monograph in the pharmacopœia.

Diluted Hydrobromic Acid
Dibuted Hydriodic Acid.
Diluted Hydrocyanic Acid.
Nitric Acid.
Sulphuric Acid.
Diluted Sulphuric Acid.
Sodium Cacodylate.
Sodium Iodide.
Sodium Phosphate.
Lithium Bromide.
Ammonium Carbonate.
Magnesium Sulphate.
Calcium Bromide.
Calcium Glycerophosphate.
Strontium Iodide.
Zinc Sulphate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
Trichloracetic Acid.
Lactic Acid.
Salicylic Acid.
Hexamethylenamine.
Phenyl Salicylate.
Pilocarpine Nitrate.
Quinine Salicylate.
Quinine Tannate.
Codeine Phosphate.

Hypochlorites *evolve odor of chlorine when treated with an acid.* This test is applied by the pharmacopœia in identifying *chlorinated lime and solution of chlorinated soda.*

Chlorates, *on heating with hydrochloric acid, evolve chlorine. On heating strongly, chlorates evolve oxygen.* These tests are used for identifying *potassium chlorate.*

Sought as impurity *in potassium nitrate*—

No yellow color should appear when 0.1 Gm. of the dry salt is sprinkled upon 1 mil of pure concentrated sulphuric acid (absence of *chlorate* and *perchlorate*).

Perchlorates.—*Sought as impurity in* potassium nitrate. See test just given.

Free bromine *liberates iodine from potassium iodide.*—(See chlorine test for diluted hydrochloric acid, in U.S.P., p. 14).

Hydrobromic acid and **bromides** *give, with silver nitrate T.S., a yellowish-white precipitate insoluble in diluted nitric acid, but soluble in ammonia water. This precipitate is silver bromide* (AgBr).

The following official chemicals are tested by this process with more or less modification as will be seen on consulting the pharmacopœia.

PRESENT AS INGREDIENTS:
Diluted Hydrobromic Acid.
Potassium Bromide.
Sodium Bromide.
Lithium Bromide.
Ammonium Bromide.
Calcium Bromide.
Hyoscyamine Hydrobromide.
Quinine Hydrobromide.

Bromides sought as impurity in—

Sodium Chloride.
Strontium Iodide (see U.S.P.).

Bromic acid and **bromates** *liberate bromine* (*which colors chloroform brown yellow*) *when treated with strong acids or other chemicals.* The following official chemicals are tested this way:

Nitric Acid.
Potassium Bromide.
Sodium Bromide.
Lithium Bromide.
Ammonium Bromide.
Calcium Bromide.
Strontium Bromide (see U.S.P.).

Free iodine *gives deep blue color to starch mucilage, which color is discharged on addition of sodium thiosulphate solution.* It also transmits to chloroform a violet color. The following official chemicals are tested this way.

PRESENT AS INGREDIENT:

Iodine.—

Sought as impurity in—

Diluted Hydrobromic Acid.
Diluted Hydriodic Acid.
Nitric Acid.
Sodium Iodide.
Ammonium Iodide.
Thymol Iodide.

Hydriodic Acid and. Iodides.—*Chlorine water liberates free iodine which gives violet color to chloroform. Silver nitrate gives yellow precipitate, insoluble in ammonia water as well as in hydrochloric acid. This precipitate is silver iodide* (AgI).

The following official chemicals are tested in this way:

PRESENT AS INGREDIENTS:

Diluted Hydriodic Acid.
Potassium Iodide.
Sodium Iodide.
Ammonium Iodide.
Strontium Iodide.

Sought as impurity in—

Diluted Hydrochloric Acid.
Potassium Bromide.
Sodium Bromide.
Sodium Chloride.
Lithium Bromide.
Ammonium Bromide.
Calcium Bromide.
Strontium Bromide.

Iodic Acid and Iodates.—*Iodine is liberated by action of acids and other chemicals, transmitting a yellowish-brown color to solution.* The following official chemicals are tested this way and for details the reader is referred to the pharmacopœia.

Sought as impurity in—

Nitric Acid.
Potassium Iodide.
Sodium Iodide.

Hydrofluoric acid and **fluorides** give off vapors which etch glass. (Fluorides must be warmed with sulphuric acid.)

Solution of Hydrogen Dioxide.—The solution is made alkaline with sodium hydroxide solution, is evaporated to dryness and is transferred to a platinum crucible. The residue treated with sulphuric acid does not etch a watch glass used as a cover for the crucible. For details see U.S.P., p. 246.

Sulphides.—*When treated with a diluted acid give off hydrogen sulphide gas, characterized by its bad smell and its ability to blacken paper moistened with lead acetate T.S.* See *Sulphurated Potassa* and *Crude Calcium Sulphide.*

Sulphurous acid and **sulphites** when heated (*the sulphites when treated with a diluted acid*) *give off sulphur dioxide gas, characterized by its suffocating odor and its ability to blacken paper moistened with mercurous nitrate, T.S.* When treated with zinc and hydrochloric acid, they evolve hydrogen sulphide gas.

The following official chemicals are tested this way:

PRESENT AS INGREDIENT:

Exsiccated Sodium Sulphite.

Sought as impurity in—

Hydrochloric Acid (strong and diluted)
Sulphuric Acid (strong and diluted).
Sodium Salicylate.
Sodium Thiosulphate (See U.S.P.).

Sulphuric Acid and Sulphates.—*Barium chloride T.S. gives a white precipitate, insoluble in hydrochloric acid.* This precipitate is barium sulphate ($BaSO_4$). The following official chemicals are tested with more or less modifications, this way. (See U.S.P.)

PRESENT AS INGREDIENTS:

Sulphuric Acid. (See U.S.P., p. 24.)
Sodium Sulphate.
Magnesium Sulphate.
Zinc Sulphate.
Alum.
Ferrous Sulphate.
Solution of Ferric Sulphate.
Solution of Ferric Subsulphate.
Copper Sulphate.
Sparteine Sulphate.
Quinine Bisulphate.
Quinine Sulphate.
Cinchonidine Sulphate.
Strychnine Sulphate.
Morphine Sulphate.
Codeine Sulphate.
Cinchonine Sulphate.

Sought as impurity in—

Diluted Hydrochloric Acid.
Phosphoric Acid.
Diluted Hydrobromic Acid.
Diluted Hydriodic Acid.
Nitric Acid.
Sodium Cacodylate.
Sodium Bromide.
Sodium Iodide.
Lithium Bromide.
Ammonium Bromide.
Ammonium Carbonate.
Solution of Magnesium Citrate.
Calcium Bromide.
Calcium Glycerophosphate.
Zinc Chloride.
Zinc Phenolsulphonate.
Zinc Valerate.
Aluminum Hydroxide.
Chromium Trioxide.
Uranium Nitrate.
Saccharated Ferrous Carbonate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
Lactic Acid.
Glycerin.
Tartaric Acid.
Citric Acid.
Hexamethylenamine.
Phenyl Salicylate.
Quinine Hydrochloride
Quinine Salicylate.
Quinine Tannate.
Codeine Phosphate. (For details, see U.S.P.)

Thiosulphates, *on treatment with a strong acid, liberate sulphur dioxide, while sulphur precipitates from the solution.* Other tests, see below. The following official chemicals are tested this way:

PRESENT AS INGREDIENT:

Sodium Thiosulphate See U.S.P. p. 400

Sought as Impurity in—

Potassium Iodide.
Sodium Iodide.
Sodium Sulphite.
Ammonium Carbonate.
(For details see U.S.P.)

Nitrous acid and nitrites *liberate iodine from potassium iodide with evolution of N_2O_4 gas; decolorize potassium permanganate when in acid solution, and are reduced to ammonia when treated with a metal and an acid.* The following official chemicals are tested this way:

Sodium Nitrite—Treat a 10 per cent. solution with potassium iodide and with hydrochloric acid; iodine is liberated and nitrogen dioxide gas escapes.

Sought as impurity in—

Sulphuric Acid.
Diluted Sulphuric Acid.
Sodium Iodide.
(For details see U.S.P.)

Nitric Acid and Nitrates.—*The free acid discharges the color of indigo solution. The acid or a nitrate, plus sulphuric acid, converts green ferrous sulphate to red-brown ferric sulphate.* If only a small quantity is used and the solutions "layered" (see below), a black-brown ring is shown at point of contact of the two liquids. Other tests given below. The following official chemicals are tested this way:

PRESENT AS INGREDIENTS:

Nitric Acid.
Potassium Nitrate
Silver Nitrate.
Fused Silver Nitrate
Pilocarpine Nitrate
Strychnine Nitrate

For details see U.S.P.

Sought as impurity in—

Diluted Phosphoric Acid.
Sulphuric Acid.
Trichloracetic Acid.
Sodium Iodide.
Ferric Chloride.
Solution of Ferric Chloride.
Tincture of Ferric Chloride.
Solution of Ferric Subsulphate.
Solution of Ferric Tersulphate.
Red Mercuric Oxide.
Bismuth and Ammonium Citrate
Bismuth Subcarbonate.
Bismuth Subgallate.
Bismuth Subsalicylate.
(For details see U.S.P.)

Boric Acid *gives the alcohol flame a green tinge.*

Borates *give similar flame when treated with a few drops of concentrated sulphuric acid and a little alcohol and then ignited.* The following official chemicals are tested in this way:

PRESENT AS INGREDIENTS:

Boric Acid.—Alcoholic or glycerinic solution burns with a flame enveloped with a green-colored mantle.

An aqueous solution of Boric Acid (1 in 50) colors blue litmus-paper red, and yellow turmeric paper brownish-red after drying, even when the solution has been acidulated with hydrochloric acid; this brownish-red color is changed to bluish-black by ammonia water.

Sodium Borate.—Borax bead dipped into glycerin and put into a non-luminous flame, colors it bright-green.

Hypophosphites *act as reducing agents; that is, when in acid solution or when heated with solutions of salts of silver, copper, and mercury, the metal is eventually precipitated.* On heating, hypophosphites yield the spontaneous combustible gas, phosphine (PH_3). (See p. 421.) The following official chemicals are tested in this way:

Hypophosphorous Acid.
Diluted Hypophosphorous Acid.
Potassium Hypophosphite.
Sodium Hypophosphite.
Calcium Hypophosphite.
(For details see U.S.P.)

Sought as impurity in—

Phosphoric Acid
Diluted Phosphoric Acid

Same as test for phosphorous acid.

Phosphorous Acid.—*Reduce solution of silver nitrate and mercuric chloride as do hypophosphites. It also gives a white precipitate with barium chloride T.S.*

Sought as impurity in—

Phosphoric Acid
Diluted Phosphoric Acid

Warm and add a few drops of silver nitrate. No turbidity occurs, if solution is properly diluted. (See U.S.P., p. 22).

Phosphoric acid and **phosphates** *give white, crystalline precipitate with magnesium mixture,*[1] *a yellow precipitate, soluble in ammonia and*

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[1] *Magnesia Mixture T.S.*—Dissolve 5.5 Gm. magnesium chloride and 7 Gm. ammonium chloride in 65 mils distilled water; add 3.5 mils ammonia water, U.S.P.; set aside a few days in a well-stoppered vessel and then filter.

nitric acid with silver nitrate T.S., a yellow precipitate on warming with ammonium molybdate T.S. The acid differs from metaphosphoric acid in coagulating albumin; from hypophosphorous acid in giving a yellow precipitate with silver nitrate. The following official chemicals are tested in this way:

PRESENT AS INGREDIENTS:

Phosphoric Acid. (See U.S.P., p. 21.)
Diluted Phosphoric Acid.
Sodium Phosphate.
Soluble Ferric Phosphate.
Codeine Phosphate.
(For details see U.S.P.)

Sought as impurity in—

Sodium Glycerophosphate.
Sodium Hypophosphite.
Potassium Hypophosphite.
Calcium Glycerophosphate.
Lactic Acid.
(For details, see U.S.P.)

Metaphosphoric Acid.—(See p. 405.)
Sought as impurity in—

Diluted Phosphoric Acid. (See test for pyrophosphoric acid.)
Phosphoric Acid.
Ferric Phosphate.

Pyrophosphoric Acid and Pyrophosphates *give a white precipitate with silver nitrate.* They also usually precipitate ferric salts.
Sought as impurity in—

Phosphoric Acid } Should not affect tincture of ferric chloride.
Diluted Phosphoric Acid }

Ferric Phosphate.—A 10 per cent. solution is deprived of its iron by addition of potassium hydroxide T.S. The filtrate is treated with magnesium mixture and the precipitated phosphate does not turn yellow when treated with silver nitrate T.S. For details see U.S.P., p. 100.

Carbonic acid and carbonates *effervesce on addition of a diluted acid.* They give white precipitates with lime water. The following official chemicals are tested in this way:

PRESENT AS INGREDIENTS:

Monohydrated Sodium Carbonate.
Sodium Bicarbonate.
Magnesium Carbonate.
Prepared Chalk.
Precipitated Calcium Carbonate.
Precipitated Zinc Carbonate.
(For details see U.S.P.)
Bismuth Subcarbonate.
Potassium Carbonate.
Potassium Bicarbonate
Lithium Carbonate.

Sought as impurity in—

Potassium Bicarbonate.—Treated with the proper amount of tenth-normal hydrochloric acid; phenolphthalein being used as indicator; pink color does not immediately occur. For details see U.S.P., p. 332. Similar tests are given for:

Sodium Bicarbonate.
Sodium Borate.
Sodium Phosphate.
Solution of Sodium Hydroxide.
Magnesium Oxide.
Calcium Oxide.
Cerium Oxalate.
Lead Acetate.
Lead Oxide.

Silicates.—*Soluble silicates (those of the alkaline metals), when treated with sulphuric acid, give a gelatinous precipitate of silicic acid,* $Si(OH)_4$. Soluble silicates can be precipitated from aqueous solution by addition of alcohol.

Permanganates give rose-colored aqueous solution and the color is discharged on addition of an oxidisable substances.

PRESENT AS INGREDIENT:

Potassium Permanganate.—See p. 369.

ORGANIC ACIDS

Acetic acid and **acetates,** *when warmed with alcohol and sulphuric acid, give off odor of acetic ether. Neutral acetates give deep red color with ferric chloride.* The following official chemicals are thus treated:

PRESENT AS INGREDIENT:

Acetic Acid.	*Zinc Acetate.*
Potassium Acetate.	*Lead Acetate.*
Sodium Acetate.	(For details see U.S.P.).

Sought as impurity in—

Ammonium Valerate } For details see U.S.P.
Zinc Valerate }

Oxalic acid and **oxalates** *give white precipitate of calcium oxalate on treatment with the solution of a calcium salt. They also give a white precipitate with barium chloride, soluble in nitric acid.*

PRESENT AS INGREDIENT:

Cerium Oxalate.

Sought as impurity in—

Diluted Hypophosphorous Acid.	*Glycerin.*
Solution of Hydrogen Dioxide.	*Lactic Acid.*
Tartaric Acid.	(For details see U.S.P.).

Butyrates *give a blue-green precipitate with copper acetate solution.* The following official chemical is thus tested:

Sought as impurity in—

Zinc Valerate.—Concentrated aqueous solution forms with a concentrated aqueous solution of copper acetate a perfectly clear fluid. For details see U.S.P., p. 495.

Lactates *give the odor of acetaldehyde when heated with unacidulated solution of potassium permanganate.*

PRESENT AS INGREDIENT:

Calcium Lactate.—See U.S.P., p. 94.

Valerates.—*Aqueous solutions of valerates when treated with sulphuric acid liberate as an oily layer free valeric acid, which is identified by its characteristic odor.* The following official chemicals are thus tested:

Ammonium Valerate.	*Zinc Valerate.*

Tartaric acid and **tartrates** *gives white, crystalline precipitate of cream of tartar with addition of the proper quantity of potassium salt.* When gently warmed with an ammoniacal solution of silver nitrate, the latter is reduced, and a silver mirror forms. The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Tartaric Acid.
Potassium Bitartrate
Potassium and Sodium Tartrate
} For details see U.S.P.

Sought as impurity in—

Potassium Citrate.
Solution of Magnesium Citrate.
Iron and Ammonium Citrate.
Iron and Quinine Citrate.
Lactic Acid.
(For details see U.S.P.).

Citric acid and citrates, *when boiled with calcium solutions deposit white granular precipitate of calcium citrate.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Citric Acid.
Potassium Citrate.
Sodium Citrate.
Lithium Citrate.
Iron and Ammonium Citrate.
Iron and Quinine Citrate.
Bismuth and Ammonium Citrate.
(For details see U.S.P.).

Sought as impurity in—

Lactic Acid.—No turbidity in heating with excess of lime water. For details see U.S.P., p. 17.

Cyanides *give a white precipitate with silver nitrate T.S., soluble in excess of cyanide solution.* When treated with ferrous and ferric salts, alkali, and then an excess of acid, a blue color (ferric ferrocyanide) is produced. The following official chemicals are tested for cyanides:

Sodium Cyanide.—A 5 per cent. solution gives with silver nitrate T.S., a white precipitate that is soluble in the cyanide solution and in ammonia water. For details see U.S.P., p. 388.

Sought as impurity in—

Potassium Iodide.
Sodium Iodide.
Strontium Iodide.
(For details see U.S.P.).

Ferrocyanides *give deep blue precipitate with ferric salts.* The following official chemicals are thus tested:

Sought as impurity in—

Sodium Cyanide.—Aqueous solution (1 : 10) acidulated with hydrochloric acid should not give blue color on addition of a drop of ferric chloride T.S.

Sodium Indigotindisulphonate.—See below.

Ferricyanides *give deep blue precipitate with ferrous salts.* The special test below employed by the pharmacopœia.

Sought as impurity in—

Sodium Indigotindisulphonate.—Shake the salt with solution of hydrogen dioxide and with solution of sodium hydroxide until the blue color disappears. Upon concentration and acidulation no blue color is produced by ferrous sulphate T.S. For details see U.S.P., p. 392.

Sodium Cyanide.—A 10 per cent. solution treated with 1 drop of ferric chloride T.S. and then with diluted hydrochloric acid does not give a blue color. For details see U.S.P., p. 389

Sulphocyanates *give intense red color with ferric salts.* The following official chemicals are thus tested:

Sought as impurity in—

Sodium Cyanide.—Treated as mentioned under ferrocyanides, no red color is produced. See U.S.P., p. 389.

Ammonium Cyanide.—Like the sodium cyanide test just given.

Benzoates *give flesh-colored precipitates with ferric salts.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Benzoic Acid.	*Ammonium Benzoate.*
Sodium Benzoate.	(For details see U.S.P.).

Sought as impurity in—

Sodium Benzosulphinide.—A 5 per cent. aqueous solution after acidulation with acetic acid gives no pinkish precipitate with ferric chloride T.S. For details see U.S.P., p. 386.

Benzosulphinide.—Test like the one just given.

Salicylates *give violet color, or precipitate with ferric salts. When warmed with concentrated sulphuric acid and methyl alcohol, it gives the odor of methyl salicylate (oil of wintergreen).* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Salicylic Acid.	*Bismuth Subsalicylate.*
Sodium Salicylate.	*Quinine Salicylate.*
Ammonium Salicylate.	(For details see U.S.P.).
Strontium Salicylate.	

Sought as impurity in—

Sodium benzosulphinide } When treated as given in the benzoate test (see above)
Benzosulphinide. } no voilet precipitate is produced.

Free salicylic acid is **sought as impurity in—**

Bismuth Subsalicylate.—When the salt is shaken with chloroform and the chloroformic filtrate is evaporated, not more than 0.5 per cent. of residue remains. For details see U.S.P., p. 83.

Phenolsulphonates *give pale violet color with ferric salts. Heated strongly, they char and give odor of phenol and the residue gives the barium chloride reaction for sulphates.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Sodium Phenolsulphonate.—A 1 per cent. solution becomes pale-violet when treated with ferric chloride T.S. No precipitate is given with barium chloride T.S. with the solution, but the ignited residue responds to the test. For details see U.S.P., p. 395.

Gallic acid and **gallates** *give, with ferric chloride T.S., a blue-black color.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Gallic Acid.
Bismuth Subgallate.

Sought as impurity in—

Free Gallic Acid.
Bismuth Subgallate.

Tannic acid and **tannates** *give, with ferric chloride T.S., a blue-black precipitate.* The acid differs from gallic acid yielding precipitates with solutions of alkaloids, glucosides, gelatin, albumin, and starch. The following official chemicals are thus tested:

PRESENT AS INGREDIENTS.

Tannic Acid.

Sought as impurity in—

Gallic Acid.

THE METALS

Potassium and **its salts** *give a violet tint to a colorless flame. When the proper quantity of tartaric acid or sodium bitartrate is added, a white crystalline precipitate (cream of tartar) results. When treated with platinic chloride T.S., a yellow, crystalline precipitate of potassio-platinic chloride is formed. When treated with sodio-cobaltic nitrite solution, a yellow precipitate falls.* The following official chemicals are tested by one or more of these tests as reference to the monograph in the pharmacopœia will show.

Present as Ingredients:

Potassium Acetate.
Potassium Bicarbonate.
Potassium Bitartrate.
Potassium Bromide.
Potassium Chlorate.
Potassium Citrate.
Alum.
Antimony and Potassium Tartrate.
Potassium and Sodium Tartrate.
Potassium Hydroxide.
Potassium Hypophosphite.
Potassium Iodide.
Potassium Nitrate.
Potassium Permanganate.

Sought as impurity in—

Sodium Acetate
Sodium Iodide } For details see U.S.P.

Sodium and **its salts** *give a brilliant yellow tint to a colorless flame.* The following official chemicals are thus tested:

Present as Ingredients:

Sodium Hydroxide.
Sodium Acetate.
Sodium Arsenate, Exsiccated.
Sodium Benzoate.
Sodium Bicarbonate.
Sodium Borate.
Sodium Bromide.
Sodium Carbonate, Monohydrated.
Sodium Chloride.
Sodium Citrate.
Sodium Cyanide.
Sodium Hypophosphite.
Sodium Iodide.
Sodium Nitrite.
Sodium Phenolsulphonate.
Sodium Phosphate.
Sodium Salicylate.
Sodium Sulphate.
Sodium Sulphite.
Sodium Thiosulphate.
Sodium and Potassium Tartrate.
Gold and Sodium Chloride.

Lithium and **its salts** *give crimson color to a non-luminous flame.* The following official chemicals are thus tested:

Present as Ingredients:

Lithium Benzoate.
Lithium Bromide.
Lithium Carbonate.
Lithium Citrate.

Ammonium salts, *when heated with other alkalies, give off ammonia gas.* The following official chemicals are thus tested:

Present as Ingredients:

Ammonium Benzoate.
Ammonium Bromide.
Ammonium Chloride.
Ammonium Iodide.
Ammonium Salicylate.
Ammonium Valerate.
Solution of Ammonium Acetate.
Solution of Iron and Ammonium Acetate.
Alum.
Iron and Ammonium Citrate.
Iron and Quinine Citrate.
Bismuth and Ammonium Citrate.
Ammoniated Mercury.

Sought as impurity in—

Potassium Bitartrate.
Potassium and Sodium Tartrate.
Solution of Zinc Chloride.
Ferric Phosphate.
Hexamethylenamine.
Benzosulphinide.

Magnesium salts *give, with sodium phosphate, in the presence of ammonium chloride and ammonia water, a white, crystalline precipitate.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Magnesium Oxide.
Magnesium Carbonate.
Magnesium Sulphate.
(For details see U.S.P.).

Sought as impurity in—

Sodium Chloride.—See U.S.P.

Calcium compounds *give, with ammonium oxalate, a white precipitate, insoluble in acetic acid, but soluble in hydrochloric acid.* The following officials are thus tested:

PRESENT AS INGREDIENTS:

Calcium Oxide.—See p. 467.
Chlorinated Lime.
Calcium Bromide.
Calcium Carbonate, Precipitated.
Prepared Chalk.
Calcium Chloride.
Calcium Hypophosphite.
Calcium Lactate.
(For details see U.S.P.)

Sought as impurity in—

Sodium Chloride.
Sodium Phosphate.
Sodium Thiosulphate.
Magnesium Oxide.
Magnesium Carbonate.
Solution of Magnesium Citrate.
(For details see U.S.P.)

Strontium compounds *give a crimson flame.* Diluted sulphuric acid and solutions of sulphates give a white precipitate of strontium sulphate, which is soluble in strong acids. The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Strontium Bromide
Strontium Iodide
Strontium Salicylate
} For details see U.S.P.

Barium salts *give a green flame. With potassium dichromate T.S. they give a yellow precipitate of barium chromate. With sulphuric acid they give a white precipitate of barium sulphate, insoluble in boiling nitric acid.* The following official chemicals are thus tested:

Sought as impurity in—

Solution of Hydrogen Dioxide.—The addition of diluted sulphuric acid to the solution should produce no turbidity or precipitate within ten minutes. For details see U.S.P., p. 247.

Diluted Hydrobromic Acid.
Diluted Hydriodic Acid.
Hypophosphorous Acid.
Potassium Bromide.
Potassium Iodide.
Sodium Bromide.
Sodium Iodide.
Ammonium Bromide.
Ammonium Chloride.
Ammonium Iodide.
Calcium Bromide.
Strontium Bromide.
Strontium Iodide.
Strontium Salicylate.
Quinine Hydrochloride.
Are tested similarly. (See U.S.P.).

Alkaline earths are sought in *uranium nitrate* by the following test: A 5 per cent. aqueous solution remains clear after adding ammonium carbonate T.S. For details see U.S.P., p. 483.

Zinc salts *give, with hydrogen sulphide T.S. or with ammonium sulphide T.S., a white precipitate of zinc sulphide; with potassium ferro-*

cyanide T.S., a white, gelatinous precipitate of zinc ferrocyanide. ***Heated with blow-pipe with cobaltous nitrate T.S. it turns a vivid green.*** **The** following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Zinc.—See p. 480.	*Zinc Oxide.*
Zinc Acetate.	*Zinc Phenolsulphonate.*
Precipitated Zinc Carbonate.	*Zinc Sulphate.*
Zinc Chloride.	(See U.S.P.).

Sought as impurity in—

Cerium Oxalate.	*Methylthionine Hydrochloride.*
Uranium Nitrate.	(See U.S.P.).

Manganese preparations, *fused with alkaline hydroxides or carbonates and an oxidizing agent (potassium nitrate or chlorate), give a green mass (alkaline manganate), and this, when boiled with water, gives a purple solution (of alkaline permanganate). Solutions of manganous salts give, with ammonium sulphide T.S., a flesh-colored precipitate of manganese sulphide.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Precipitated Manganese Dioxide.—See U.S.P., p. 266.

Sought as Impurity in—

Uranium Nitrate.—See U.S.P.

Aluminum salts *give, with ammonia water, a white, gelatinous precipitate of aluminum hydroxide, insoluble in excess of ammonia water; with potassa or soda they give the same precipitate, but it is soluble in excess of potassa or soda.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Alum.—See p. 490.

Sought as impurity in—

Potassium Bitartrate.	*Lithium Carbonate.*
Sodium Phosphate.	*Cerium Oxalate.*
	(See U.S.P.).

Chromic acid salts, *when warmed with sulphuric acid and alcohol, change to a green liquid which has the odor of aldehyde.* This test is not employed in the case of the only official chromium compound, chromium trioxide. (See p. 598.)

Uranium salts *give a yellow precipitate with alkalies, a dark brown precipitate with ammonium sulphide and a yellow precipitate with sodium phosphate.* The following official salt is thus tested:

Uranium Nitrate

Uranous compounds are tested for (in uranium nitrate) as follows:

Uranium Nitrate.—A 5 per cent. aqueous solution, acidulated with sulphuric acid does not decolorize a definite volume of permanganate V.S. For details see U.S.P., p. 483.

Ferrous salts *give, with potassium ferricyanide, a blue color or precipitate.* The following official salts are thus tested:

PRESENT AS INGREDIENTS:

Ferrous Sulphate.	*Saccharated Ferrous Carbonate.*
	(See U.S.P.).

Sought as impurity in—

Ferric Chloride.
Solution of Ferric Chloride.
Solution of Ferric Sulphate.
Solution of Ferric Subsulphate.
(See U.S.P.).

Ferric salts (or **iron**) *give a red-brown precipitate of ferric hydroxide with ammonia or soda or potassa. With potassium ferrocyanide they give a deep blue color or precipitate, and with potassium sulphocyanate, a blood-red color.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Ferric Chloride.
Solution of Ferric Chloride.
Tincture of Ferric Chloride.
Solution of Ferric Sulphate.
Solution of Ferric Subsulphate
Iron and Ammonium Citrate.
Iron and Quinine Citrate.
Soluble Ferric Phosphate.
(See U.S.P.).

Sought as impurity in—

Ammonium Bromide.
Lithium Carbonate.
Magnesium Oxide.
Magnesium Carbonate.
Calcium Bromide.
Alum.
Uranium Nitrate.
Antimony and Potassium Tartrate.
Exsiccated Sodium Arsenate.
Lead Acetate.
(See U.S.P.).

Arsenic and **its compounds** *give, with hydrogen sulphide, a bright yellow precipitate of arsenic sulphide, which is soluble in ammonium carbonate T.S. and in ammonium sulphide T.S.* With ammoniacal solution of copper sulphate[1] they give a green precipitate, while acid solutions dropped on a sheet of metallic copper coats the metal with a gray film of metallic arsenic. See also Marsh's Test (p. 522), Bettendorf's Test (p. 523 and below), and Gutzeit's Test (p. 523 and below). The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Arsenic Trioxide.—A 1 per cent. solution is made yellow by addition of hydrogen sulphide T.S. Upon acidulation with hydrochloric acid, there precipitates lemon-yellow arsenic trisulphide, which is completely soluble in ammonium carbonate T.S. For details see U.S.P., p. 65.

Sodium Arsenate.—A 5 per cent. solution gives a white precipitate with barium chloride and a dark red one with silver nitrate. A test is also given for the presence of *arsenite*, based upon the fact that when the silver arsenate precipitate just described, is dissolved in ammonia water and is then boiled, black metallic silver should not be precipitated. For details see U.S.P., p. 382.

The Arsenic Test in Official Chemicals.—All official chemicals in which arsenic is to be sought as impurity are tested by one of two processes, the *modified Gutzeit test* (called in the present pharmacopœia the "*Test for arsenic*" and the *Bettendorf test*.

The two tests are given in the pharmacopœia, with extreme minuteness, since it is imperative that all of the chemicals and all parts of the apparatus employed be free from arsenic.

The Test for Arsenic.—Summarized, the pharmacopœial monograph first explains the *apparatus* in which the test should be conducted; this consisting of a wide-mouthed bottle of about 50 mils capacity provided with a one-holed rubber stopper through which passes a percolator-shaped exit tube in which can be placed a pledget of glass wool and a roll of lead acetate test paper. This tube is closed with a one-holed cork stopper through which passes a smaller tube in which is inserted mercuric bromide test paper. Next, is described the *standard arsenical test solution*, which is a faintly acidulated solution made from arsenic trioxide, sodium hydroxide sulphuric acid and water, so prepared that 1 mil contains exactly $\frac{1}{1000}$ of 1 milligramme. This solution is used to produce the standard stain.

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[1] **Cupric Ammonium Sulphate Test Solution.**—A solution of cupri-tetrammonium sulphate, $Cu(NH_3)_4SO_4+H_2O$. To copper sulphate T.S. add ammonia water, drop by drop, until the precipitate at first formed is nearly, but not completely redissolved, then filter. This solution should be freshly made when required.

It is next provided that the chemical to be tested be prepared by treating in aqueous solution with a mixture of equal volumes of sulphuric acid and water; that this fluid be treated with a saturated aqueous solution of sulphurous acid, and that the mixture be then evaporated on a water-bath until it is free from the odor of sulphurous acid.

The next step is the preparation of standard stains by running the test with known quantities of the standard arsenical test solution by generating hydrogen in the test apparatus from zinc and sulphuric acid (stannous chloride solution being also added) and then generating arsine by introducing the arsenical solution into the flask. (See p. 522.) This arsine produces on the mercuric bromide paper a yellow stain and that in proportion to the amount of arsine present. A blank test, using all of the chemicals except the arsenical test solution should be run in the test apparatus and should give negative results. The chemical to be tested should be handled as the standard arsenical solution was and should show on the mercuric bromide solution not more than 1 part of arsenic in 100,000.

Lastly, the monograph points out that sulphites, sulphides, thiosulphates and phosphides interfere with the reaction as does also antimony and it directs that those containing antimony must be tested by the Bettendorf method. For details of the test, which should be read by the student, see U.S.P., p. 584.

The following official chemicals are submitted to the test just given and, for details of preliminary manipulation, the reader is referred to the appropriate monograph in the pharmacopœia:

Solution of Hydrogen Dioxide.
Precipitated Sulphur.
Boric Acid.
Hydrochloric Acid.
Diluted Hydrobromic Acid.
Nitric Acid.
Sulphuric Acid.
Phosphoric Acid.
Hypophosphorous Acid.
Potassium Acetate.
Potassium Citrate.
Potassium Hypophosphite.
Sodium Borate.
Sodium Citrate.
Sodium Hypophosphite.
Sodium Phosphate.
Sodium Sulphate.
Sodium Thiosulphate.
Magnesium Sulphate.
Calcium Hypophosphite.
Alum.
Aluminum Hydroxide.
Cerium Oxalate.
Reduced Iron.
Zinc Acetate.
Zinc Phenolsulphonate.
Zinc Sulphate.
Zinc Valerate.
Glycerin.
Glucose.
Methylthionine Hydrochloride.

Bettendorf's Arsenic Test.—This is used to test bismuth and antimony compounds, for the presence of arsenic. It has already been described on p. 523; so here it need merely be stated that the pharmacopœial monograph directs that the tested substance is to be dissolved in a clean test-tube in concentrated hydrochloric acid, that saturated stannous chloride T.S. is then added and that the mixture is then set aside for thirty minutes. A brownish color indicates arsenic. For details see U.S.P., p. 586. This is the method used in testing the following preparations:

CHEMICAL.

Bismuth Subnitrate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
Bismuth Betanaphthol.
Antimony and Potassium Tartrate.
(For details see U.S.P.).

Antimony and its compounds *give, in acid solution with hydrogen sulphide, an orange precipitate of antimony sulphide, soluble in ammonium sulphide T.S.* The following chemical is thus tested:

PRESENT AS INGREDIENT:

Antimony and Potassium Tartrate.—A 5 per cent. acidulated aqueous solution gives with hydrogen sulphide T.S. an orange-red precipitate, which is soluble in ammonium sulphide and potassium sulphide solutions. For details see U.S.P., p. 50.

Cadmium and its compounds *give, in acid solution with hydrogen sulphide, a yellow precipitate, insoluble in ammonium sulphide T.S.*

Copper salts *give, with potassium ferrocyanide T.S., a red-brown precipitate of copper ferrocyanide. With ammonia water they give a blue-white precipitate of cupric hydroxide, which, when treated with excess of ammonia water, dissolves to an azure-blue liquid* (see Cupric Ammonium Sulphate T.S., p. 873). *If a bright piece of steel is dipped into a copper solution, it becomes coated with metallic copper.* The following official chemicals are thus tested:

PRESENT AS INGREDIENT:

Copper Sulphate.—A drop of a 5 per cent. solution upon a bright piece of iron, deposits a red film of metallic copper.

Ammonia water first produces a pale blue precipitate of cupric hydroxide, which redissolves in excess forming a deep azure-blue solution. For details see U.S.P., p. 128.

Sought as impurity in—

Bismuth Subnitrate.
Bismuth Subcarbonate.
Bismuth Subsalicylate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Exsiccated Sodium Arsenate.
Lead Acetate.
(See U.S.P.).

Bismuth salts *in concentrated acid solution yield, when poured into large amount of water, a white precipitate* (of the "sub" salt of bismuth). *With hydrogen sulphide, solutions of bismuth salts give a black precipitate of bismuth sulphide.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Bismuth Subnitrate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
(See U.S.P.).

Lead salts *give, with hydrochloric acid, a white precipitate of lead chloride, which is sparingly soluble in water; with diluted sulphuric acid it gives a white precipitate of lead sulphate; with hydrogen sulphide, a black precipitate of lead sulphide; with potassium iodide, a yellow precipitate of lead iodide.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Lead Oxide.—A 10 per cent. solution in diluted nitric acid, after neutralization yields a black precipitate with hydrogen sulphide, a yellow precipitate with potassium iodide and a white precipitate with diluted sulphuric acid. For details see U.S.P., p. 329.

Lead Acetate.—Like test for lead oxide just given except than an aqueous solution is employed.

Sought as impurity in—

Tartaric Acid.
Potassium Bitartrate.
Sodium Arsenate.
Sodium and Potassium Tartrate.
Bismuth Subnitrate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
(See U.S.P.).

Sulphuric Acid.—Purely physical; no precipitate should form on adding 4 or 5 volumes of alcohol; any lead present will precipitate.

Mercury Salts (both "ous" and "ic").—*Give with hydrogen sulphide a black precipitate of mercuric sulphide.*

Mercurous Salts.—*Give with hydrochloric acid a white precipitate of mercurous chloride.*

Mercuric Salts.—*Give no precipitate with hydrochloric acid. They give with ammonia a white precipitate (ammoniated mercury); with potassium iodide, a red precipitate of mercuric iodide, soluble in excess, and with* *potassium hydroxide, a yellow precipitate of mercuric oxide.* The following official chemicals are thus tested:

PRESENT AS INGREDIENTS:

Ammoniated Mercury.—The solution of the salt in diluted nitric acid gives with potassium iodide T.S. a red precipitate. For details see U.S.P., p. 220.

Corrosive Mercuric Chloride.—A 5 per cent. aqueous solution gives a white precipitate with ammonia water, a black one with hydrogen sulphide, and a red one with potassium iodide. For details see U.S.P., p. 214.

Silver Salts.—*Give with hydrochloric acid, a curdy white precipitate of silver chloride, soluble in ammonia water, but insoluble in nitric acid.* The following official chemicals are thus tested:

PRESENT AS INGREDIENT:

Silver Nitrate.

Sought as impurity in—

Bismuth Subnitrate.
Bismuth Subcarbonate.
Bismuth and Ammonium Citrate.
Bismuth Subgallate.
Bismuth Subsalicylate.
(See U.S.P.).

Group Impurities.—Aside from the tests for specific impurities given on the foregoing pages, the pharmacopœia in several cases directs tests for groups of impurities, such as *heavy metals, excess of alkali,* and *non-volatile impurities.*

Test for Heavy Metals.—The monograph in the present pharmacopœia directs that 10 mils of an acidulated aqueous 2 per cent. solution is to be mixed with an equal volume of freshly prepared hydrogen sulphide solution allowed to stand in a warm place for half an hour in a well-stoppered test-tube, and its color then compared with the color of a straight hydrogen sulphide solution, kept under similar conditions. Volatile oils are to be shaken with faintly acidulated distilled water after which, the mixture is to be saturated with hydrogen sulphide. In neither case, should the tested fluid be darkened. For details see U.S.P., p. 586.

Below are tabulated the official chemicals thus tested, and for details of method of preparation before applying the test; the reader is referred to the pharmacopœia.

Solution of Hydrogen Dioxide.
Boric Acid.
Hydrochloric Acid.
Diluted Hydrobromic Acid.
Diluted Hydriodic Acid.
Nitric Acid.
Sulphuric Acid.
Phosphoric Acid.
Hypophosphorous Acid.
Potassium Hydroxide.
Potassium Acetate.
Potassium Bicarbonate.
Potassium Bitartrate.
Potassium Bromide.
Potassium Carbonate.
Potassium Chlorate.
Potassium Citrate.
Potassium and Sodium Tartrate.
Potassium Iodide.
Potassium Nitrate.
Sodium Hydroxide.
Solution of Sodium Hydroxide.
Sodium Acetate.
Sodium Benzoate.
Sodium Borate.
Ammonium Bromide.
Ammonium Carbonate.
Ammonium Chloride.
Ammonium Iodide.
Ammonium Salicylate.
Ammonium Valerate.
Magnesium Oxide.
Magnesium Carbonate.
Magnesium Sulphate.
Calcium Bromide.
Calcium Carbonate, Precipitated.
Calcium Chloride.
Calcium Glycerophosphate.
Calcium Hypophosphite.
Calcium Lactate.
Strontium Bromide.
Strontium Iodide.
Strontium Salicylate.
Cerium Oxalate.
Aluminum Hydroxide.
Alum.
Ferrous Sulphate.
Gold and Sodium Chloride.
Uranium Nitrate.
Zinc Oxide.

Sodium Bromide.
Sodium Carbonate.
Sodium Bicarbonate.
Sodium Chloride.
Sodium Citrate.
Sodium Glycerophosphate.
Sodium Hypophosphite.
Sodium Iodide.
Sodium Nitrite.
Sodium Perborate.
Sodium Phenolsulphonate.
Sodium Phosphate.
Sodium Pyrophosphate.
Sodium Salicylate.
Sodium Sulphite.
Sodium Sulphate.
Sodium Thiosulphate
Lithium Benzoate.
Lithium Bromide.
Lithium Carbonate.
Lithium Citrate.
Lithium Salicylate.
Ammonia Water.
Ammonium Benzoate.
Zinc Acetate.
Zinc Carbonate.
Zinc Chloride.
Zinc Phenolsulphonate.
Zinc Sulphate.
Zinc Valerate.
Copper Sulphate.
Lactic Acid.
Citric Acid.
Tartaric Acid.
Glycerin.
Glucose.
Hexamethylenamine
Antipyrine.
Citrated Caffeine.
Caffeine Sodio-benzoate.
Sodium Cacodylate.
Methyl Salicylate.
Oil of Anise.
Oil of Cassia.
Oil of Cajuput.
Salicin.
Quinine Tannate.

Free Alkali Tests:

Potassium Iodide.—A solution of 1 Gm. salt in 10 mils of water and 0.1 mil tenth-normal sulphuric acid V.S. does not become colored on adding phenolphthalein. For details see U.S.P., p. 340.

Similar tests are provided for the following chemicals:

Sodium Bromide.
Sodium Iodide.
Sodium Hypophosphite.
Lithium Bromide.
Lithium Carbonate.
Lithium Citrate.
Solution of Lime.
Precipitated Zinc Carbonate.
Zinc Oxide.
Thymol Iodide.
(For details see U.S.P.)

Free Acid Tests:

Solution of Hydrogen Dioxide.—Not more than 2 mils tenth-normal potassium hydroxide V.S. required to neutralize 25 mils of solution. For details see U.S.P., p. 246.

Non-volatile Impurity Tests:

Diluted Hydrobromic Acid.—On evaporation of 25 mils of the acid not more than 0.0025 Gm. dried residue should be left. For details see U.S.P., p. 13.

Similar tests are provided in the pharmacopœia for:

Hydrochloric Acid
Nitric Acid } For details see U.S.P.
Sulphuric Acid

SYSTEMATIC CHEMICAL ANALYSIS

The pharmacopœial tests given on preceding pages, while important and valuable, give us information that is somewhat disjointed.

If we suspect that a liquid contains zinc, we may try the tests for zinc given on p. 480, but suppose the liquid contains magnesium and iron as well as zinc, how would we then proceed? Or suppose we had no idea what metals the solution contains, how would we begin?

In analytic chemistry, as in everything else in science, system is the secret of success, and it is to systematic analysis to which we now must refer. This is performed by separating the several elements in a solution into groups by the use of certain chemicals which we call "group reagents." The important group reagents are:

First, hydrochloric acid (HCl); second, hydrogen sulphide (H_2S); third, ammonium sulphide (NH_4HS); fourth, ammonium carbonate, $(NH_4)_2CO_3$; applying them one after another to the solution under examination.

Now, suppose we have a solution containing *all* the elements used in pharmacy, we would take the solution and add

Hydrochloric acid, when there would be precipitated out Hg (ous), Pb, and Ag as insoluble chlorides. The liquid is separated from the precipitate by filtration, and through the filtrate we would pass

Hydrogen sulphide (*gas*), when we would get a precipitate of: (*a*) Cd, Cu, Hg, (ic), Pb, Bi. (*b*) As, Sb, and Sn as insoluble sulphides. The precipitate can be separated into groups "a" and "b" by digestion in NH_4HS, in which group "b" dissolves, leaving group "a" behind. In the meanwhile the filtrate from the H_2S precipitate is treated with NH_4Cl, NH_4OH, and

Ammonium sulphide, which precipitates from it (*a*) Fe, *Al, Cr;* (*b*) *Zn,* Mn, Co, and Ni. All save those in italics as sulphides. The italicized as hydroxides.

Group "a" of this precipitate, when dissolved in hydrochloric and nitric acid, is precipitated by ammonia water. Group "b," under same treatment, is not. By this method the two groups are separated. The filtrate from the NH_4HS precipitate is now treated with

Ammonium carbonate, when down comes Ba, Sr, and Ca, as insoluble carbonates. To the filtrate from this precipitate is added

Ammonium phosphate, when there is precipitated Mg as phosphate. The filtrate will now hold only Li, Na, K, and NH_4, and this is considered the last group.

By this method we have separated the metals into seven groups, as follows:

I.	Li	K	Na	NH_4
II.	Mg	Ca	Sr	Ba
III.	Zn	Mn	Co	Ni
IV.	Al	Fe	and	Cr
V.	As	Sb	Sn	
VI.	Cd	Cu	Hg	(ic) Bi.
VII.	Hg	(ous)	Pb	and Ag.

Only the symbols are given above, as it is expected that the preceding chapters of this book have been read and mastered.

Some books on analytic chemistry number these groups differently, beginning with Hg (ous) and Ag as the first group, but this is of small importance, the main point being the separation of the twenty-four metals into seven simple groups, from which, in turn, the metals themselves can be separated without great difficulty. How this separation of the small groups is carried on is beyond the scope of this book, and the reader is referred to one of the books on analytic chemistry mentioned in Preface.

A summary of the more important individual tests may be useful. The following metals give characteristic color with *borax bead:*

Manganese	Amethyst.
Cobalt	Blue.
Copper	Green.
Iron	Red.

The following flame tests are characteristic:

Strontium (also lithium)	Crimson.
Calcium	Red-yellow.
Copper	Blue-green.
Potassium	Violet.
Sodium	Yellow.
Boric acid and alcohol	Green.

The following hydrogen sulphide precipitates are characteristic:

White	Zinc (from alkaline solution).
Flesh color	Manganese (from alkaline solution).
Yellow	Arsenic and tin (from acid solution).
Orange	Antimony (from acid solution).
Blacks	Mercury, copper, lead (from acid solution).

The other elements will not precipitate with H_2S.

The following special tests are characteristic:

SUBSTANCE.	REAGENT.	REACTION.
Acids and their salts.		
H_2SO_4.	Barium chloride.	White precipitate.
HCl.	Silver nitrate.	White precipitate.
HBr.	Silver nitrate.	Yellow precipitate.
Phosphoric acid.	Magnesium sulphate.	White crystalline precipitate.
Carbonic acid.	Lime water.	White precipitate.
Nitric acid.	Green $FeSO_4$ solution.	Changed to *red* or *black* $Fe_2(SO_4)_3$ solution.
Thiosulphuric acid.	Sulphuric acid.	Vapors of SO_2 and precipitate of sulphur.
Sulphurous acid.	Sulphuric acid.	Vapors of SO_2.
Tartaric acid.	Silver nitrate.	Mirror of metallic silver.
Acetic acid.	H_2SO_4 and alcohol.	Odor of acetic ether.
Metallic Salts.		
Zinc.	Hydrogen sulphide.	White precipitate.
Calcium.	Ammonium oxalate.	White precipitate.
Magnesium.	Sodium phosphate.	White precipitate.
Iron (ic).	Potassium ferrocyanide.	Blue precipitate.
Iron (ous).	Potassium ferricyanide.	Blue precipitate.
Silver.	Sodium chloride.	White precipitate.
Aluminum.	Solution of soda.	White gelatinous precipitate.
Lead.	Potassium chromate.	Yellow precipitate.
Arsenic Antimony	Test by Marsh's, Fleitmann's, or Gutzeit's test, as explained on p. 522.	

Tests for organic chemicals are too numerous and varied to admit of a tabulated statement; hence the reader is referred to the pharmacopœial tests for such substances, found scattered through Part IV.

CHAPTER LIV

QUANTITATIVE ANALYSIS

INORGANIC VOLUMETRIC ANALYSIS

As mentioned on p. 859, we are able to examine chemicals **not merely as** to ingredients, but also can ascertain the quantity of each ingredient. The latter work is the object of quantitative analysis. The three methods of quantitative analysis usually employed **are volumetric analysis, gravimetric analysis, and gasometric analysis.**

VOLUMETRIC ANALYSIS

is the most largely employed process of quantitative analysis as far as pharmacy is concerned; the pharmacopœia directing this method in the estimation of the strength of drugs whenever possible. The volumetric processes of the pharmacopœia, with but two exceptions (the use of Fehling's solution and the use of Koppeschaar's solution, p. 917), fall into four groups:

I. Acidimetry or alkalimetry.

II. The use of iodine volumetric solution or its complement, sodium thiosulphate volumetric solution.

III. Oxidation with potassium permanganate volumetric solution or with potassium dichromate volumetric solution.

IV. The use of silver nitrate volumetric solution or its complementse potassium sulphocyanate volumetric solution and sodium chlorid, volumetric solution.

Before discussing these several groups of volumetric analysis it is advisable to quote what the pharmacopœia says about volumetric solutions, with special emphasis laid on the explanation of *normal solutions* *decinormal solutions*, and *centinormal solutions*.

The ninth revision of the pharmacopœia (Part II, page 555) gives explicit general directions as to aids to accuracy in volumetric work and these directions should be carefully read by all students. It then proceeds to discuss volumetric solutions as outlined below.

Normal $\left(\frac{N}{1}\right)$ *volumetric solutions* according to the pharmacopœia are "those which contain in 1000 mils, in any stated reaction, the chemical equivalent of 1 gramme of hydrogen." It then proceeds to state that a normal solution of a univalent reagent contains in 1 liter, the molecular weight of that reagent expressed in grammes; that of a bivalent reagent one-half of the molecular weight expressed in grammes; if trivalent, one-third of the molecular weight expressed in grammes. The examples cited are: hydrochloric acid, HCl, has the molecular weight 36.47; therefore 1 liter of normal solution should contain 36.47 Gm. absolute HCl. Sulphuric acid, H_2SO_4, has the molecular weight, 98.09; hence 1 liter of normal solution will contain 98.09 ÷ 2 or 49.045 Gm. absolute H_2SO_4.

Potassium hydroxide KOH, has the molecular weight, 56.11; hence 1 liter of normal solution will contain 56.11 Gm. absolute KOH.

Potassium dichromate has the molecular weight, 294.2 and liberates 3 atoms of oxygen. One molecule of it is therefore equal to 6 atoms of hydrogen and 1 liter of its normal solution should therefore contain 294.2 ÷ 6 or 49.0334 Gm. absolute dichromate.

The monograph further explains why 1 liter of tenth-normal potassium permanganate contains 3.1606 Gm. absolute permanganate (see p. 897) and points out that a tenth-normal, in hundredth-normal, in fiftieth-normal, in double-normal and in half-normal volumetric solutions contain respectively one-tenth, one one-hundredth, one-fiftieth, twice and half the amount of reagent found in the normal solution. It further gives the two styles of abbreviations used for these strengths of volumetric solutions:

Tenth-normal $\frac{N}{10}$ or 0.1 *n*.

Hundredth-normal $\frac{N}{100}$ or 0.01 *n*.

Fiftieth-normal $\frac{N}{50}$ or 0.02 *n*.

Double-normal $\frac{2N}{1}$ or 2 *n*.

Half-normal $\frac{N}{2}$ or 0.5 *n*.

Lastly it discusses empiric solutions, those not adjusted upon a molecular basis, but which are usable since their exact strengths are known and the proper factor necessary in calculations can be determined. All of these details should be carefully read in the pharmacopœia (p. 556) by the student.

Acidimetry and Alkalimetry.—This group includes the estimation of alkalis by use of a volumetric solution of an acid or the estimation of acids by the use of a volumetric solution of an alkali. The process can be best illustrated by a typical example. Taking the pharmacopœial estimation of potassium hydroxide, for instance, we find (p. 891) that it is accomplished by use of normal volumetric solution of hydrochloric acid, and the theory of this kind of estimation is that sufficient to the acid solution is added to make the product exactly neutral—to make pure potassium sulphate. To know when this neutrality is reached, we use some substance which by change of color will show whether the liquid is acid or alkaline. Litmus can be used for this purpose, for we learned long since that litmus turns red with acids and blue with alkalis. But litmus is not exact enough. We need some substances which will change their tint when there is but a fraction of 1 per cent. of free acid or free alkali present. Such a coloring-matter is called an *indicator*, and chief among those used in this class of volumetric analysis are the following:

Phenolphthalein, red with alkalis, colorless with acids.
Methyl orange, yellow with alkalis, red with acids.
Hematoxylin, violet with alkalis, yellow with acids.
Iodeosin, pink with alkalis, colorless with acids.

The new pharmacopœia contains (Part II, p. 579) a full discussion of indicators which should be carefully read by the student.

Turning to the process, suppose we combine potassium hydroxide with sulphuric acid to a neutral salt. Absolutely pure potassium hydroxide is KOH; molecular weight, 56.11. Absolutely pure sulphuric acid is H_2SO_4; molecular weight, 98.09. The molecular weights just given are estimated from the "exact" atomic weights given by the pharmacopœia and not from the "round number" atomic weights found in elemental table on p. 352.

The reaction between potassium hydroxide and sulphuric acid can be expressed by the following equation:

$$\begin{array}{ccccccccc} 2KOH & + & H_2SO_4 & = & K_2SO_4 & + & 2H_2O. \\ 2\times56.11 & & 98.09 & & 174.27 & & 2\times18.016 \\ \text{or } 112.22 & & & & & & \text{or } 36.032 \end{array}$$

We see from the equation that absolute potassium hydroxide combines with absolute sulphuric acid in the proportion of 112.22 Gm. of the hydroxide to 98.09 Gm. of the acid, and were we to prepare solutions of these two bodies of such strength that equal volumes of the two solutions would exactly neutralize each other, the solutions would have to be prepared to the ratio of 112.22 to 98.09.

To make it plainer: were we to prepare a liter of solution containing exactly 112.22 Gm. absolute potassium hydroxide, a liter of solution of sulphuric acid to neutralize it would have to hold 98.09 Gm. of absolute acid; or if we prepared a solution of potassium hydroxide containing in one liter 56.11 Gm. of absolute hydroxide (½ of 112.22), then a liter of solution of sulphuric acid that would neutralize the hydroxide must contain one-half of 98.09 or 49.045 Gm. of absolute sulphuric acid, and such is the strength of normal sulphuric acid, as reference to p. 883 will show. The foundation to acidimetric work is the strength of normal potassium hydroxide solution and normal sodium hydroxide solution, each of which represents in each liter of solution the number of grammes of absolute hydroxide equal to the molecular weight of the substance employed. Thus, normal potassium hydroxide solution contains 56.11 Gm. of hydroxide to the liter, and normal sodium hydroxide contains 40.01 Gm. of hydroxide to the liter. On the other hand, the dibasic acids—sulphuric acid and oxalic acid—are made into normal volumetric solutions by using to a liter of solution, the number of grammes of acid corresponding to *half* the molecular weight, since it takes only half a molecule (if the phrase is permissible) of either of these acids to neutralize one molecule of either of the two alkalis.

The use of a volumetric solution in testing is simple. The volumetric solution is poured into a graduated tube called a burette (see Fig. 23, p. 46), while the substance to be examined, after careful weighing, is dissolved and so placed that the contents of the burette can be gradually run into it. The indicator—usually phenolphthalein—is poured into the solution to be examined. Let us suppose this substance is an alkali: then the solution will be colored purple red. Into this the volumetric solution is added gradually and stopped the moment that a drop of the reagent discharges the color of the solution, which will mean that the solution is no longer alkaline. Then a simple reckoning—amount of volumetric solution in burette *before*, minus amount *after*, dropping into tested solution, will give us the number of mils of volumetric solution used in neutralizing the tested substance, and from these figures we can, by aid of the pharmacopœia, estimate strength of the tested substance.

Applying these directions to the estimation of potassium hydroxide, suppose we weigh out 1 gramme of the chemical, dissolve it in water, and titrate it; treat it with normal sulphuric acid V.S. (V.S. meaning volumetric solution). We find the gramme of potassium hydroxide takes 16 mils normal sulphuric acid (abbreviated nH_2SO_4) to neutralize it. From the equation—

$$\underset{112.22}{2KOH} + \underset{98.09}{H_2SO_4} = \underset{174.27}{K_2SO_4} + \underset{36.032}{2H_2O}$$

we see that 98.09 Gm. absolute H_2SO_4 = 112.22 Gm. absolute KOH. We have learned that a liter of $nH_2SO_4 = \frac{98.02}{2}$ Gm. or 49.045 Gm. absolute H_2SO_4. Since 49.045 Gm. absolute $H_2SO_4 = \frac{112.22}{2}$ Gm., or 56.11 Gm. absolute KOH, we find that

1000 mils $nH_2SO_4 = 56.11$ Gm. absolute KOH.
1 mil $nH_2SO_4 = 0.05611$ Gm. absolute KOH.
Hence 16 mils $nH_2SO_4 = 16 \times 0.05611$ Gm. absolute KOH.
0.89776 Gm. absolute KOH.

Hence 1 Gm. potassium hydroxide we examined contained 0.89776 gm. absolute KOH, and was therefore almost 90 per cent. absolute.

Reference to U.S.P. (p. 576) will show that the factor "1 mil $nH_2SO_4 =$ 0.05611 Gm. absolute KOH" is found under the table of values of 1 mil normal sulphuric acid V.S., and it need here be said that each particular value of 1 mil normal acid found therein has been worked out by process of reasoning just given. The same obtains with the equivalent tables found under the several volumetric solutions, and incidentally it might be noted that one mil of a normal acid or of normal alkali is represented as the same number of milligrammes of the substance tested as the molecular weight of the substance if it be monobasic or monacid, half the molecular weight if it be dibasic or diacid, one-third the molecular weight if it be tribasic or triacid. The following volumetric solutions are used in acidimetry and alkalimetry:

NORMAL SULPHURIC ACID VOLUMETRIC SOLUTION

$H_2SO_4 = 98.09$. 49.045 Gm. in 1000 mils.

Condensed Recipe.

Dilute 30 mils of sulphuric acid U.S.P. with enough distilled water to make 1050 mils. Standardize this either by titration with normal potassium hydroxide V.S. or weighing out a definite amount of anhydrous sodium carbonate and titrating this with the acid solution. On estimating the strength of the latter, it is diluted with water to the exact normal strength, which is to be proven by a titration of the diluted product. For details see U.S.P., p. 575 where the arithmetic of dilution is also discussed.

The pharmacopœia also gives the equivalent value of normal sulphuric acid (the so-called *factor*) for a list of 27 chemicals assayed with that reagent. As an understanding of this factor is essential to the comprehension of volumetric methods it is worthy of explanation at this place.

On p. 881, it was pointed out that when sulphuric acid and potassium hydroxide were combined (as in a titration) each 49.045 grammes of the absolute acid neutralized 56.11 grammes of the absolute hydroxide. Then we learned that 1000 mils of normal sulphuric acid contained 49.045 Gm. H_2SO_4 and therefore was the equivalent, in a titratiom, of 56.11 Gm. KOH. It therefore follows that 1 mil of normal sulphuric acid represents 56.11 ÷ 1000 or 0.05611 Gm. KOH and this we find is stated in the table of "equivalent values" (or factors) of normal sulphuric acid which is pointed in the pharmacopœia. The factor of course, bears a direct relation to the molecular weight of the chemical in question depending, as do volumetric solutions, on the hydrogen value of the substance under consideration.

Turning to the U.S.P. list of 27 chemicals assayed with normal sulphuric acid we find:

The equivalent factor (grammes of chemical represented by 1 mil of normal acid) of the following chemicals is *the molecular weight of the chemical divided by* 1000.

Ammonia gas, NH_3; ammonium acetate, $NH_4C_2H_3O_2$; lithium salicylate, $LiC_7H_5O_3$; potassium acetate, $KC_2H_3O_2$, potassium bicarbonate, $KHCO_3$; potassium bitartrate, $KHC_4H_4O_6$; potassium hydroxide, KOH; sodium acetate, $NaC_2H_3O_2$; sodium bicarbonate, $NaHCO_3$; sodium hydroxide, NaOH; and sodium salicylate, $NaC_7H_5O_3$.

The equivalent factor (grammes of chemical represented by 1 mil of normal acid) of the following chemicals is *the molecular weight of the substance divided by* 2000:

Ammonium carbonate $(NH_4)_2CO_3$; calcium hydroxide $Ca(OH)_2$; calcium oxide, CaO; lead acetate, $Pb(C_2H_3O_2)_2+3H_2O$; lithium carbonate, Li_2CO_3; magnesium oxide, MgO; potassium carbonate, K_2CO_3; potassium and sodium tartrate, $KNaC_4H_4O_6+4H_2O$; sodium borate $Na_2B_4O_7+10H_2O$; sodium carbonate, anhydrous, Na_2CO_3; sodium carbonate, monohydrated, $Na_2CO_3+H_2O$; zinc oxide, ZnO.

Of the remaining chemicals, the factor of two—ammonium carbonate U.S.P., $NH_4HCO_3.NH_4NH_2CO_2$ and potassium citrate $K_3C_6H_5O_7+H_2O$—is *the molecular weight of the chemical divided by* 3000; the factor of one—lead subacetate, $Pb_2O(C_2H_3O_2)_2$—is *the molecular weight of the chemical divided by* 4000, while the factor of the last—

magnesium carbonate, $(MgCO_3)_4Mg(OH)_2+5H_2O$—is *the molecular weight divided by* 10,000.

HALF-NORMAL SULPHURIC ACID VOLUMETRIC SOLUTION

$H_2SO_4=98.09$. 24.5225 Gm. in 1000 mils.

Condensed Recipe.

Dilute 500 mils of normal sulphuric acid with enough distilled water to make 1000 mils. Specific directions are given as to use of indicators with this solution for details see U.S.P., p. 576. A list of 18 equivalent factors are given. Of these 12 are chemicals mentioned under normal sulphuric acid; the factors, of course, being just one-half the normal-acid values. The remaining six the factor of one—sodium benzoate, $NaC_7H_5O_2$—is the molecular weight divided by 2000; while the factor of the other five—lithium citrate, anhydrous, $LiC_6H_5O_7$; lithium citrate, crystallized, $LiC_6H_5O_7+4H_2O$; potassium citrate, $K_3C_6H_5O_7$; sodium citrate, anhydrous, $Na_3C_6H_5O_7$; and sodium citrate, crystallized, $Na_3C_6H_5O_7+2H_2O$—is the molecular weight divided by 6000.

TENTH-NORMAL SULPHURIC ACID VOLUMETRIC SOLUTION

$H_2SO_4=98.09$. 4.9045 Gm. in 1000 mils.

Dilute 100 mils of normal sulphuric acid, with sufficient distilled water at the same temperature to measure 1000 mils.

Provision is also made to dilute sulphuric acid directly and to standardize with anhydrous sodium carbonate. Careful directions are given as to use of indicators. For details see U.S.P., p. 577.

The pharmacopœia gives a list of equivalent factors for 24 chemicals assayed with tenth-normal acid. Of these, four—potassium hydroxide, calcium hydroxide, anhydrous sodium carbonate and zinc oxide—have a factor, which is, of course one-tenth of the value given under the normal acid. The remainder are the alkaloids and with fifteen of these; aconitine, atropine, cephaline, cinchonidine, cinchonine, cocaine, coniine, emetine, hydrastine, morphine (amorphous and crystalline), physostigmine, pilocarpine, quinine and strychnine—the factor (grammes of alkaloid represented by 1 mil of tenth-normal acid) is the *molecular weight divided by* 10,000; the factor of one brucine—is *the molecular weight divided by* 20,000, while the remaining four are factors calculated for the alkaloidal mixtures found in aconite, nux vomica, ipecac and mydriatic drugs respectively.

FIFTIETH-NORMAL SULPHURIC ACID VOLUMETRIC SOLUTION

$H_2SO_4=98.09$. 0.9809 Gm. in 1000 mils.

Condensed Recipe.

Dilute 200 mils of tenth-normal sulphuric acid with enough distilled water to make 1000 mils. The pharmacopœial monograph directs that the strength of this be determined with half-normal potassium hydroxide V.S. See U.S.P., p. 578. The factors given are for aconitine, atropine, cinchonidine, cinchonine, combined alkaloids of cinchona and of ipecac. Of course, the factor in the case of each of the alkaloids is one-fifth that of the tenth-normal sulphuric acid factor.

TENTH-NORMAL OXALIC ACID VOLUMETRIC SOLUTION

$H_2C_2O_4+2H_2O=126.05$ 6.3025 Gm. in 1000 mils.

Condensed Recipe.

Dissolve 6.45 Gm. purified oxalic acid in enough distilled water to make 1000 mils. Standardize this with tenth-normal potassium hydroxide V.S., using phenol-phthalein as indicator and then dilute to exactly tenth-normal strength. For details see U.S.P., p. 562.

The pharmacopœia gives the factor for 13 chemicals assayed with tenth-normal oxalic acid. In the case of three of these—ammonia gas, potassium hydroxide and sodium hydroxide—the factor (grammes of chemical represented by 1 mil of the tenth-normal acid) is *the molecular weight divided by* 10,000; with eight—calcium carbonate, calcium hydroxide, calcium oxide, lead, lead acetate, lead oxide, lead peroxide and manganese dioxide—the factor is *the molecular weight divided by* 20,000; with one—lead subacetate, the factor is the *molecular weight divided by* 40,000; while with the last—potassium permanganate—the factor (as explained on page 898) is *the molecular weight divided by* 50,000.

NORMAL HYDROCHLORIC ACID VOLUMETRIC SOLUTION

HCl = 36.47 36.47. Gm. in 1000 mils.

Condensed Recipe.

Mix 110 mils of hydrochloric acid with enough distilled water to make 1000 mils. Standardize with normal potassium hydroxide V.S., using methyl-orange as indicator. Then dilute to exactly normal strength. For details including the arithmetic of dilution, see U.S.P., p. 559.

The pharmacopœia gives factors for nine chemicals, when tested with normal hydrochloric acid. Eight of these are in the list given under normal sulphuric acid (p. 883) and are, obviously the same figures as there given. The ninth is sodium cacodylate, the factor for which is the molecular weight divided by 1000.

HALF-NORMAL HYDROCHLORIC ACID VOLUMETRIC SOLUTION

HCl = 36.47. 18.235 Gm. in 1000 mils.

Condensed Recipe.

Dilute 500 mils of normal hydrochloric acid V.S. with enough water to make 1000 mils. For details see U.S.P., p. 560).

The pharmacopœia gives factors for 29 chemicals assayed with half-normal hydrochloric acid, V.S. Of these 20 are substances for which factors have been given under normal or half-normal sulphuric acid. In the case of three of the remaining chemicals—benzaldehyde, citral, and sodium glycerophosphate—the factor (grammes of chemical represented by 1 mil of half-normal acid) is *the molecular weight divided by* 2000; while with the remaining six—calcium lactate; cinnamic aldehyde, magnesium hydroxide, sodium tartrate, and strontium salicylate (anhydrous and crystallized) the factor is *the molecular weight divided by* 4000.

NORMAL POTASSIUM HYDROXIDE VOLUMETRIC SOLUTION

KOH = 56.11 56.11 Gm. in 1000 mils

Condensed Recipe.

Dissolve 75 Gm. specially purified potassium hydroxide in enough boiled distilled water to make 1050 mils. Standardize this titrating with an accurately weighed quantity (4.7035 Gm.) of potassium bitartrate, using phenolphthalein as indicator. The above-mentioned amount of bitartrate requires 25 mils of normal potassium hydroxide for neutralization and the solution being standardized must be diluted accordingly. For details, including arithmetic of dilution see U.S.P., p. 563. The pharmacopœia also permits the standardization of this solution with normal sulphuric acid. It also gives directions for preservation of the alkaline volumetric solutions. The pharmacopœia gives factors for twenty-four chemicals assayed with normal potassium hydroxide V.S. In the case of seventeen of these chemicals: acetic acid, $HC_2H_3O_2$; acetic acid anhydride $(CH_3CO)_2O$; ammonia gas, NH_3; ammonium chloride, NH_4Cl; boric acid (with glycerin) H_3BO_3; formaldehyde, $HCHO$; hydrated chloral, CCl_3CHO+H_2O; hydriodic acid, HI; hydrobromic acid, HBr; hydrochloric acid, HCl; hypophosphorous acid, HPH_2O_2; lactic acid, $HC_3H_5O_3$; nitric acid, HNO_3; potassium bitartrate, $KHC_4H_4O_6$; sodium bitartrate, $NaHC_4H_4O_6$; sodium hydroxide, $NaOH$; and trichloracetic acid, CCl_3COOH; the factor (grammes of substance represented by 1 mil of normal potassium hydroxide V.S.) is *the molecular weight divided by* 1000.

With five—oxalic acid, $H_2C_2O_4+2H_2O$; phosphoric acid (with phenolphthalein), H_3PO_4; sulphuric acid, H_2SO_4; sulphuric acid anhydride, SO_3; and tartaric acid, $H_2C_4H_4O_6$—the factor is *the molecular weight divided by* 2000; while with the remaining two—citric acid, $H_3C_6H_5O_7$; and paraformaldehyde $(HCHO)_3$—the factor is *the molecular weight divided by* 3000.

HALF-NORMAL POTASSIUM HYDROXIDE VOLUMETRIC SOLUTION

KOH = 56.11 28.055 Gm. in 1000 mils

Condensed Recipe.

Dilute 500 mils of exactly normal potassium hydroxide V.S. with enough recently boiled distilled water to make 1000 mils. The pharmacopœia also provides for its standardization with potassium bitartrate and discusses the proper methods of preserving it see U.S.P., p. 565. The pharmacopœia gives factors for eighteen chemicals assayed with half-normal potassium hydroxide V.S., all of which are listed under normal potassium hydroxide V.S. It is obvious that the factors for the half-normal solution are exactly one-half of the factors for normal solution.

In preparing these volumetric solutions the dry chemicals are weighed on an appropriate scale, and the finished standardized solution brought to the exact volume in an accurately measured flask (see Fig. 21, of 1000-mil flask on p. 46). The other apparatus required in volumetric analysis are pipettes (see Fig. 22, p. 46), burettes, which have just been described, and a number of chemical flasks of appropriate size.

TENTH-NORMAL POTASSIUM HYDROXIDE VOLUMETRIC SOLUTION

$KOH = 56.11$ 5.611 Gm. in 1000 mils

Condensed Recipe.

Dilute 100 mils of exactly normal potassium hydroxide V.S. with enough recently boiled distilled water to make 1000 mils. It can also be made and standardized directly with potassium bitartrate. For details see U.S.P., p. 565, where directions for keeping are also given.

Of the factors given in the pharmacopœia, four are for those chemicals given under normal or half-normal potassium hydroxide V.S. These factors are, of course, one-tenth that of the normal or one-fifth half-normal factors. The fifth given is for beta-eucaine hydrochloride and this is *the molecular weight divided by* 10,000.

HUNDREDTH-NORMAL POTASSIUM HYDROXIDE VOLUMETRIC SOLUTION

$KOH = 56.11$ 0.5611 Gm. in 1000 mils

Condensed Recipe.

Dilute 100 mils of tenth-normal potassium hydroxide V.S. with enough recently boiled distilled water to make 1000 mils. Factors for potassium bitartrate and for sulphuric acid are given. These are, of course, one-tenth of the tenth-normal factor or one one-hundredth of the normal factor.

HALF-NORMAL ALCOHOLIC POTASSIUM HYDROXIDE VOLUMETRIC SOLUTION

$KOH = 56.11$ 28.055 Gm. in 1000 mils

Condensed Recipe.

First purify the alcohol to be used (freeing it from aldehyde) by treatment with silver nitrate followed by very pure potassium hydroxide. When the silver has all precipitated as hydroxide, filter the alcohol and prepare with it a solution consisting of 35 Gm. potassium hydroxide, 20 mils of distilled water and enough of the alcohol to make 1 liter. Standardize this by titration with potassium bitartrate and then dilute with the purified alcohol to exactly half-normal strength. Permission is given to standardize the solution with half-normal hydrochloric acid and directions are also given for preserving the finished solution. For details see U.S.P., p. 567.

The pharmacopœia also gives the factors for six chemicals assayed with half-normal alcoholic potassium hydroxide V.S. In the case of all of these, the factor (grammes of substance represented by 1 mil of the half-normal alcoholic alkali) is *the molecular weight of the chemical divided by* 2000.

NORMAL SODIUM HYDROXIDE VOLUMETRIC SOLUTION

$NaOH = 40.01$ 40.01 Gm. in 1000 mils

Condensed Recipe.

Dissolve 50 Gm. sodium hydroxide U.S.P. in enough recently boiled distilled water to make 1 liter. This is then standardized with potassium bitartrate and is then diluted in exactly normal strength. For details (including the factors for three chemicals, which are the same as given under normal potassium hydroxide V.S.) see U.S.P., p. 573).

DOUBLE-NORMAL SODIUM HYDROXIDE VOLUMETRIC SOLUTION

$NaOH = 40.01$ 80.02 Gm. in 1000 mils

Condensed Recipe.

Dissolve 90 Gm. sodium hydroxide U.S.P. in enough recently boiled distilled water to make 1 liter. Standardize either with potassium bitartrate or with normal sulphuric acid. For details see U.S.P., p. 573.

TENTH-NORMAL BARIUM HYDROXIDE VOLUMETRIC SOLUTION

$Ba(OH)_2+8H_2O = 315.51$ 15.775 Gm. in 1000 mils

Condensed Recipe.

Dissolve 18 Gm. crystallized barium hydroxide in 1000 mils of recently boiled distilled water. After filtering, standardize with either tenth-normal sulphuric or tenth-normal hydrochloric acid V.S. using phenolphthalein as indicator and dilute with freshly boiled distilled water to exactly tenth-normal strength. For details, including method of preservation, see U.S.P., p. 558.

The pharmacopœia gives factors for six chemicals titrated with tenth-normal barium hydroxide V.S. Of these, two are, hydrochloric acid and sulphuric acid. In the case of the other four—ammonium benzoate, ammonium salicylate, benzoic acid and salicylic acid—the factor (grammes of chemical represented by 1 mil of the tenth-normal solution) is *the molecular weight of the chemical divided by* 10,000.

OFFICIAL CHEMICALS ASSAYED WITH NORMAL POTASSIUM HYDROXIDE V.S.

Hydrochloric Acid.—Accurately weigh about 3 mils of hydrochloric acid, dilute with distilled water and titrate with normal potassium hydroxide V.S. Indicator, methyl orange. Strength from 31 to 33 per cent. HCl. Each mil of normal KOH, V.S. = 0.03647 Gm. HCl. Each Gm. U.S.P. acid = 8.5 to 9.05 mils normal KOH, V.S. For details see U.S.P., p. 13.

The above assay, as all other assays of the present pharmacopœia, omits all explanation of calculation of results, so it is here necessary to state that the mathematical equation used in calculating strength is

$$\frac{\text{mils nKOH used} \times \text{proper factor} \times 100}{\text{weight of assayed chemical}} = \text{percentage.}$$

Referring to the table of values under normal Potassium Hydroxide V.S. on p. 885, it will be seen that 1 mil of the volumetric solution equals 0.03647 Gm. absolute hydrochloric acid. This represents the "proper factor" mentioned in the equation and each time a chemical is assayed with a volumetric solution, reference to the table of factors for that solution found in the pharmacopœia, and discussed at some length on page 883 of this book. The following chemicals are assayed by use of normal KOH and the manipulation closely follows that for hydrochloric acid given above. In each case an approximate amount of the chemical is taken and is then carefully and exactly weighed, the titration is then performed with the volumetric solution, the proper indicator telling the end of the reaction, the point where the acid reaction is changed to alkalinity. As noted in the hydrochloric acid assay, the present pharmacopœia furnishes, in addition to the "proper factor," a statement as to how many mils of the volumetric solution will be required to neutralize 1 gramme of the chemical assayed. In the following table, all of the data suggested above is presented, but for other details, such as amount of water required for dilution or solution of the chemical, is referred to the pharmacopœia itself.

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator employed
Acetic Acid	6.0 mils	6.0 to 6.16 mils	Phenolphthalein
Diluted Acetic Acid	25.0 mils	0.97 to 1.05 mils	Phenolphthalein
Glacial Acetic Acid	2.5 mils	16.5 mils	Phenolphthalein
Citric Acid	3.0 mils	14.2 mils	Phenolphthalein
Diluted Hydrobromic Acid	20.0 mils	1.17 to 1.3 mils	Methyl orange
Hydrochloric Acid	3.0 mils	8.5 to 9.05 mils	Methyl orange
Diluted Hydrochloric Acid	10.0 mils	2.6 to 2.9 mils	Methyl orange
Hypophosphorous Acid	7.0 mils	4.54 to 4.84 mils	Methyl orange
Diluted Hypophosphorous Acid	25.0 mils	1.44 to 1.6 mils	Methyl orange
Lactic Acid	2.5 mils	9.44 to 10.0 mils	Phenolphthalein
Nitric Acid	2.0 mils	10.63 to 10.95 mils	Methyl orange
Sulphuric Acid	1.0 mils	18.96 to 19.35 mils	Methyl orange
Diluted Sulphuric Acid	20.0 mils	1.94 to 2.14 mils	Methyl orange
Tartaric Acid	3.0 Gm.	13.26 mils	Phenolphthalein
Trichloracetic Acid	4.0 Gm.	6.06 to 6.12 mils	Phenolphthalein
Potassium Bitartrate	6.0 Gm.	5.2 mils	Phenolphthalein

The following assays with normal potassium hydroxide V.S. are too intricate for tabulation; hence are printed in fairly complete abstract.

Hydrated Chloral.—Accurately weigh about 4 Gm. of hydrated chloral, dissolve in water, add 30 mils nKOH, V.S. After standing, titrate the residual alkali with nH_2SO_4, V.S. Indicator, phenolphthalein. Strength, not less than 99.5 per cent. $C_2HCl_3O + H_2O$. Each mil nKOH, V.S. = 0.1654 Gm. of $C_2HCl_3O + H_2O$. Each Gm. chloral = not less than 6.02 mils nKOH, V.S.

This type of assay is called a "residual assay." It will be noted that the chloral hydrate is treated with a known excess of normal alkali, which is partly used up in converting the chloral into chloroform. The excess of alkali, that not used in splitting up the chloral, is then titrated with normal acid. If exactly 4 grammes of hydrated chloral were taken and the excess alkali took 6 mils of normal acid for neutralization, then it means that 30 − 6 or 24 mils of nKOH were used by the hydrated chloral. If, as stated above each gramme of hydrated chloral corresponds to 6.02 mils of nKOH then it follows that the 24 mils used in the reaction meant 4 grammes of hydrated chloral.

Solution of Formaldehyde.—Accurately weigh about 3 mils of solution of formaldehyde dilute with water and then add 50 mils nKOH, V.S., followed by 50 mils of a neutral solution of hydrogen dioxide. After oxidation is complete, titrate with nH_2SO_4, V.S. Indicator, litmus T.S. Strength, not less than 37 per cent. HCHO. Each mil KOH, VS. = 0.03002 Gm. HCHO. Each Gm. HCHO = 12.3 mils nKOH, V.S. For details see U.S.P., p. 245.

The principle of this assay is that formaldehyde is oxidized by hydrogen dioxide to formic acid and this acid is then neutralized by titration with nKOH. The same method is employed in assaying.

Paraformaldehyde.—For details see U.S.P., p. 310.

Aromatic Sulphuric Acid.—Accurately weigh 10 mils of this acid, dilute with water and boil the liquid for six hours in a flask provided with a reflux condenser. Then cool, dilute with water and titrate with nKOH, V.S. Strength, 19 to 21 per cent. H_2SO_4. Each mil nKOH, V.S. = 0.049045 Gm. H_2SO_4. Each Gm. aromatic acid = 3.87 to 4.28 mils nKOH, V.S. For details see U.S.P., p. 25.

The object of boiling the aromatic acid with water is to insure the breaking up of the ethyl sulphates into the free sulphuric acid.

OFFICIAL CHEMICALS ASSAYED WITH NORMAL SODIUM HYDROXIDE V. S.

Boric Acid.—Accurately weigh about 2.5 Gm. well-dried boric acid, dissolve in water, add 50 mils of glycerin and titrate with nNaOH, V.S. Indicator, phenolphthalein. Strength, not less than 99.5 per cent. H_3BO_3. Each mil nNaOH, V.S. = 0.06202 Gm. H_3BO_3. Each Gm. boric acid = 16.04 mils nNaOH, V.S. For details see U.S.P., p. 9.

While the direct titration of boric acid with alkalies does not give satisfactory results, the addition of glycerin as suggested in the assay just given furnishes accurate figures.

OFFICIAL CHEMICALS ASSAYED WITH TENTH-NORMAL BARIUM HYDROXIDE V.S.

Benzoic Acid.—Accurately weigh about 0.5 Gm. well-dried benzoic acid, dissolve in 25 mils of neutral diluted alcohol and titrate with $n/10$ $Ba(OH)_2$, V.S. Indicator, phenolphthalein. Strength, not less than 99.5 per cent. $HC_7H_5O_2$. Each mil $n/10$ $Ba(OH)_2$, V.S. = 0.012205 Gm. $HC_7H_5O_2$. Each Gm. citric acid = 81.5 mils $n/10$ $Ba(OH)_2$, V.S. For details see U.S.P., p. 8.

Salicylic Acid.—Exactly as in the assay for benzoic acid, except that 1 gramme of the acid requires 71.9 mils of the $Ba(OH)_2$, V.S.

Ammonium Benzoate.—Weigh accurately about 0.5 Gm. of the well-dried benzoate, dissolve in water, acidulate, shake out with three portions of chloroform. Evaporate the chloroformic extract, dissolve the residue in neutral diluted alcohol and titrate with $n/10$ $Ba(OH)_2$, V.S. Indicator, phenolphthalein. Strength, not less than 98 per cent. $NH_4C_7H_5O_2$. Each mil $n/10$ $Ba(OH)_2$, V.S. = 0.013908 Gm. $NH_4C_7H_5O_2$ Each Gm. benzoate = 70.5 mils $Ba(OH)_2$, V.S. For details, see U.S.P., p. 42.

Ammonium Salicylate.—Exactly as in the assay for ammonium benzoate, except that 1 gramme of the salicylate requires 63.2 mils of $Ba(OH)_2$, V.S.

OFFICIAL CHEMICAL ASSAYED WITH TENTH-NORMAL POTASSIUM HYDROXIDE, V. S.

Betaeucaine Hydrochloride.—Accurately weigh 0.5 Gm. of the well-dried hydrochloride in 100 mils of neutral alcohol, and titrate with $n/10$ KOH, V.S. Indicator, phenolphthalein. Strength, not less than 99 per cent. $C_{15}H_{21}NO_2HCl$. Each mil $n/10$ KOH, V.S. = 0.0283 Gm. $C_{15}H_{21}NO_2HCl$. Each Gm. U.S.P. hydrochloride = 34.9 mils $n/10$ KOH, V.S. For details see U.S.P., p. 77.

OFFICIAL CHEMICALS ASSAYED WITH NORMAL SULPHURIC ACID, V.S.

Ammonia Water.—Accurately weigh about 5 mils of ammonia water, dilute with water and titrate with nH_2SO_4, V.S. Indicator, litmus or methyl orange T.S. Strength, 9.5 to 10.5 per cent. NH_3. Each mil nH_2SO_4, V.S. = 0.01703 Gm. NH_3. Each Gm., U.S.P., ammonia water = 5.57 to 6.16 mils nH_2SO_4, V.S. For details see U.S.P., p. 53.

The following chemicals are assayed by use of normal H_2SO_4 and an outline of the manipulation, having such details as amount of water used (for which the student should refer to the pharmacopœia) is given below.

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator employed
Stronger Ammonia Water	2 mils	15.85 to 17.02	Litmus or methyl orange
Potassium Bicarbonate	4 Gm.	9.9 mils	Methyl orange
Potassium Carbonate	3 Gm.	14.33 mils	Methyl orange
Sodium Bicarbonate	3 Gm.	11.78 mils	Methyl orange
Monohydrated Sodium Carbonate	2.5 Gm.	16.05 mils	Methyl orange

The following chemicals are assayed with normal H_2SO_4 by "residual titration;" that is, the chemical is dissolved in a known excess of the normal acid V.S. and the solution is then titrated with normal KOH. Thus in the case of lithium carbonate (see U.S.P., p. 258) we start in with 50 mils nH_2SO_4 which, of course, would require 50 mils nKOH for neutralization. If we start in with exactly 1.5 Gm. lithium carbonate and dissolve this in 50 mils nH_2SO_4 and if on titration 10 mils nKOH are required for neutralization, it follows that $50-10$ or 40 mils nH_2SO_4 were used to neutralize 1.5 gm. lithium carbonate. Now the official assay states that each gramme of the carbonate requires 26.7 mils nH_2SO_4; the 1.5 grammes of our carbonate took 40 mils nH_2SO_4; hence the real

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator
Ammonium Carbonate	2.0 Gm.	17.6 to 18.8 mils	Methyl orange
Magma of Magnesia	5.0 Gm.	2.23 to 2.57 mils	Methyl orange
Magnesium Carbonate	1.0 Gm.	19.44 mils	Methyl orange
Magnesium Oxide	0.5 Gm.	47.62 mils	Methyl orange
Zinc Carbonate	1.0 Gm.	16.79 mils	Methyl orange
Zinc Oxide	1.5 Gm.	24.3 mils	Methyl orange

value of our carbonate is 40÷26.7. Finish the calculation and see how close to the original weight the quotient is. Other chemicals assayed by "residual titration" with nH_2SO_4 and nKOH are tabulated below. For details see U.S.P.

In the case of the magnesium carbonate and oxide, the present of traces of the corresponding calcium compounds are taken into consideration. The following assay present unusual features which are summarized below.

Solution of Ammonium Acetate.—Accurately weigh about 25 mils of the solution, make alkaline with potassium hydroxide solution and distil the liberated ammonia into 50 mils nH_2SO_4, V.S. After the distillation, titrate the residual acid with nKOH, V.S. Indicator, methyl orange. Strength, not less than 7 per cent. $NH_4C_2H_3O_2$. Each mil nH_2SO_4 = 0.07707 Gm. $NH_4C_2H_3O_2$. Each Gm. U.S.P. solution = at least 0.91 mil nH_2SO_4, V.S. For details, see U.S.P. p. 237.

OFFICIAL CHEMICALS ASSAYED WITH HALF-NORMAL SULPHURIC ACID V.S.

This reagent is used in assaying the alkali salts of organic acids and the manipulation is described in the pharmacopœia (Part II, Test 6). The test may be summarized as follows:

Outline of Assay for Alkali Salts of Organic Acids.—Accurately weigh about 2 grammes of the salt, then carbonize at red heat, then extract the carbonized mass with $n/2$ H_2SO_4, V.S. properly diluted and titrate the filtrate with $n/2$ KOH, V.S., using methyl orange as indicator. From the number of mils of $n/2$ KOH, V.S. used, the number of mils of $n/2$ H_2SO_4, V.S. can be deduced and this number times the factor for the particular salt in question, will give the amount of absolute salt in the sample examined. For details see U.S.P., p. 589.

Caffeine Sodio-benzoate is assayed for sodium benzoate by this method; the pharmacopœia directing that the benzoate content must be between 50 and 54 per cent.

The following chemicals are similarly tested:

Chemical	Each gramme of chemical corresponds to mils of V.S.
Solution of Potassium Citrate	1.57 mils
Lithium Citrate	21.0 mils
Potassium Acetate	20.2 mils
Potassium Citrate	18.3 mils
Potassium and Sodium Tartrate	14.03 to 14.73 mils
Sodium Acetate	14.62 to 15.32 mils
Sodium Benzoate	13.72 mils
Sodium Citrate	20.0 mils
Sodium Salicylate	12.43 mils

Seidlitz Powder is assayed with half-normal sulphuric acid both for sodium bicarbonate and for potassium and sodium tartrate. The first assay is a residual titration; while the second one is the one prescribed for alkali salts of organic acids. Both are outlined below.

Compound Effervescing Powder.

Assay for Sodium Bicarbonate.—Dissolve 2 grammes of the contents of the blue paper in water, add 20 mils of $n/2$ H_2SO_4, V.S., boil until about one-half of the original volume remains, then titrate the excess of acid with $n/2$ KOH, V.S.; using phenolphthalein as indicator. Strength, 23 to 27 per cent. $NaHCO_3$.

Each mil $n/2$ H_2SO_4, V.S. = 0.0420 Gm. $NaHCO_3$. Each Gm. seidlitz mixture = 5.28 to 6.43 mils $n/2$ H_2SO_4, V.S.

Assay for Potassium and Sodium Tartrate.—Treat 2 grammes of the contents of the blue paper as directed in the assay for alkali salts of organic acids. (See above.) Assay should show 73 to 78 per cent. $KNaC_4H_4O_6$.

OFFICIAL CHEMICALS ASSAYED WITH TENTH-NORMAL SULPHURIC ACID

Solution of Calcium Hydroxide.—Titrate 50 mils of the solution with $n/10$ H_2SO_4, V.S. Indicator, phenolphthalein. Strength, not less than 0.14 per cent. $Ca(OH)_2$.

Each mil $n/10$ H_2SO_4, V.S. = 0.0037 Gm. $Ca(OH)_2$. Each mil U.S.P. solution = 0.38 mil $n/10$ H_2SO_4, V.S. For details see U.S.P., p. 239.

Zinc Stearate.—Accurately weigh about 1 Gm. zinc stearate, boil with 50 mils $n/10$ H_2SO_4, V.S. for ten minutes and then cool. Titrate excess of acid with $n/10$ KOH, V.S. Indicator, methyl orange. Strength, 13 to 15.5 per cent. ZnO.

Each mil $n/10$ H_2SO_4, V.S. = 0.00406 Gm. ZnO. Each Gm. U.S.P. stearate = 32 to 38.1 mils $n/10$ H_2SO_4, V.S. For details see U.S.P., p. 494.

OFFICIAL CHEMICALS ASSAYED WITH NORMAL HYDROCHLORIC ACID V.S.

Potassium Hydroxide.—Accurately weigh about 10 Gm. potassium hydroxide, dissolve in water, add barium chloride solution, to precipitate sulphates and carbonates, filter and titrate exactly one-fifth of the filtrate with nHCl, V.S. Indicator, phenolphthalein. Strength, at least 85 per cent. KOH.

Each mil nHCl, V.S. = 0.05611 Gm. KOH. Each Gm. U.S.P. hydroxide = 15.15 mils nHCl, V.S. For details, see U.S.P., p. 339.

Resembling the assay just given are the following:

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator
Solution of Potassium Hydroxide	20 Gm.	0.8 mil	Phenolphthalein
Sodium Hydroxide...........	10 Gm.	22.5 mils	Phenolphthalein
Solution of Sodium Hydroxide.	20 Gm.	1.12 mils	Phenolphthalein

The assays for borax and for sodium cacodylate are simple, direct titrations. These may be summarized as follows:

Sodium Borate.—Accurately weigh about 5 Gm. sodium borate, dissolve in water and titrate with nHCl, V.S. Indicator, methyl orange. Strength, 52.32 to 54.92 per cent. $Na_2B_4O_7$.

Each mil nHCl, V.S. = 0.1010 Gm. $Na_2B_4O_7$. Each Gm. U.S.P. borate = 5.18 to 5.44 mils nHCl, V.S. For details see U.S.P., p. 385.

Sodium Cacodylate.—Accurately weigh about 2.5 Gm. sodium cacodylate, neutralize the solution and titrate with nHCl, V.S. Indicator, methyl orange. Strength, 72 to 75 per cent. $Na(CH_3)_2AsO_2$.

Each mil nHCl, V.S. = 0.1600 Gm. $Na(CH_3)_2AsO_2$. Each Gm. U.S.P., cacodylate = 4.5 to 4.69 Gm. nHCl, V.S. For details see U.S.P., p. 386.

OFFICIAL CHEMICALS ASSAYED WITH HALF-NORMAL HYDROCHLORIC ACID V.S.

Strontium Salicylate.—Accurately weigh 2 Gm. well-dried strontium salicylate, carbonize at red heat, extract carbonized residue with 30 mils $n/2$ HCl, V.S. and then titrate the filtrate with nKOH, V.S. Indicator, methyl orange. Strength, at least 99 per cent. $Sr(C_7H_5O_3)_2 + 2H_2O$.

Each mil $n/2$ HCl, V.S. = 0.99435 Gm. $Sr(C_7H_5O_3)_2 + 2H_2O$. Each Gm. U.S.P. salicylate = 9.96 mils $n/2$ HCl, V.S. For details see U.S.P., p. 414.

Calcium Lactate.—Accurately weigh about 2 Gm. lactate, incinerate, dissolve the residue in 50 mils $n/2$ HCl V.S. and titrate the acid liquid with $n/2$ KOH, V.S. Indicator, methyl orange. Strength, not less than 98 per cent. $Ca(C_3H_5O_3)_2$.

Each mil $n/2$ HCl, V.S. = 0.05454 Gm. $Ca(C_3H_5O_3)_2$. Each Gm. U.S.P. lactate = 17.97 mils $n/2$ HCl V.S. For details see U.S.P., p. 94.

IODOMETRY

By this term we mean those volumetric assays in which we use volumetric solution of iodine or volumetric solution of sodium thiosulphate, or both.

As already explained (p. 378), iodine in solution is decolorized by use of sodium thiosulphate, and this decoloration, like all chemical actions, takes place between definite proportions of the two chemicals, the equation being:

$$\underset{\substack{2\times 126.92\\ \text{or } 253.84}}{I_2} + \underset{\substack{2\times 248.22\\ \text{or } 496.44}}{2Na_2S_2O_3,5H_2O} = 2NaI + Na_2S_4O_6 + 10H_2O.$$

We see from this equation that 253.84 Gm. iodine take 496.44 Gm. crystallized sodium thiosulphate to complete the reaction—to completely decolorize it. Therefore, if we prepare a decinormal iodine solution (12.69 Gm. to the liter), we can calculate that this 12.69 Gm. iodine will take $\frac{12.69}{253.84}\times 496.44 = 24.82$ Gm. sodium thiosulphate, which amount is exactly the quantity needed to make 1 liter of decinormal sodium thiosulphate solution. Hence equal volumes of the two decinormal solutions exactly react with each other.

In titrating iodine solution with thiosulphate solution we either add the thiosulphate solution until the brown-yellow color of the iodine is discharged, or, better still, we use as indicator starch mucilage, which we have already learned strikes a deep blue color with iodine (p. 378). The moment all the iodine in a given solution is taken up by the thiosulphate, the blue color is discharged.

Were the sole use of iodine solution and thiosulphate solution the estimation of the strength of these two chemicals, the value of iodometry would be limited. Far more extended, however, is its application, because of the fact that iodine, when treated with reducing agents, is converted into hydriodic acid or iodides, as shown in the following equations:

$$(a)\ I_2 + \underset{\text{Sulphurous oxide.}}{SO_2} + 2H_2O = \underset{\substack{\text{Hydriodic}\\ \text{acid.}}}{2HI} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{H_2SO_4}.$$

$$(b)\ 2I_2 + \underset{\substack{\text{Arsenous}\\ \text{oxide.}}}{As_2O_3} + 2H_2O = 4HI + \underset{\substack{\text{Arsenic}\\ \text{oxide.}}}{As_2O_5}.$$

$$(c)\ I_2 + Fe = FeI_2,$$

and thus loses its ability to color starch mucilage blue. Hence if we treat a known excessive quantity of iodine solution with any of the reducing agents just mentioned, by titrating the excess of iodine remaining after the reaction with thiosulphate solution, we can calculate how much iodine was used by the reducing chemical and thus estimate the amount of chemical itself.

On the other hand, potassium iodide when treated with oxidizing agents liberates a proportional quantity of its iodine, as is shown in the following equations:

$$(d)\ KI + Br = KBr + I.$$

$$(e)\ KI + Cl = KCl + I.$$

$$(f)\ 3KI + \underset{\substack{\text{Chromic}\\ \text{oxide.}}}{CrO_3} + 6HCl = CrCl_3 + 3KCl + 3H_2O + I_3$$

$$(g)\ KI + \underset{\substack{\text{Ferric}\\ \text{chloride.}}}{FeCl_3} = FeCl_2 + KCl + I.$$

and by titrating this liberated iodine with thiosulphate solution the amount of the oxidizing agent can be deduced.

The pharmacopœial preparation of decinormal iodine solution and of decinormal thiosulphate solution are given below.

TENTH-NORMAL IODINE VOLUMETRIC SOLUTION

$I = 126.92$ 12.692 Gm. in 1000 mils

Condensed Recipe.

Either dissolve exactly 12.692 Gm. purified iodine in a solution of 18 Gm. potassium iodide in 300 mils of distilled water; finally diluting to 1000 mils. Or, dissolve about 14 Gm. iodine U.S.P. in a solution of potassium iodide and water; diluting the solution to 1000 mils. In the latter case, the iodine solution is standardized with tenth-normal sodium thiosulphate solution (see p. 892) and is then diluted to exactly tenth-normal strength. For details see U.S.P., p. 561.

The pharmacopœia gives equivalent factors for sixteen chemicals assayed with tenth-normal iodine V.S. In the case of five of these, mercurous chloride, HgCl; mercurous iodide, HgI; mercury ("ous" form) Hg; and sodium thiosulphate (anhydrous and crystalline) the factor (grammes of chemical represented by 1 mil of tenth-normal iodine) is *the molecular weight of the chemical divided by* 10,000.

In the case of six of the chemicals—antimony and potassium tartrate $K(SbO)C_4H_4O_6 + \frac{1}{2}H_2O$; arsenic iodide, AsI_3; potassium sulphate, $K_2SO_4 + 2H_2O$; sodium bisulphite, $NaHSO_3$; sodium sulphate, Na_2SO_3; and sulphur dioxide, SO_2—the factor is *the molecular weight divided by* 20,000; with iron (in ferrous compounds and arsenic (in compounds) the factor is *the atomic weight divided by* 20,000; in the case of arsenic trioxide As_2O_3 and of calcium sulphide, CaS, the factor is *molecular weight divided* by 40,000; while in the case of acetone $(CH_3)_2CO$, the factor is the *molecular weight divided* by 60,000.

TENTH-NORMAL SODIUM THIOSULPHATE VOLUMETRIC SOLUTION

$Na_2S_2O_3 + 5H_2O = 248.22$ 24.822 gm. in 1000 mils

Condensed Recipe.

Dissolve about 30 Gm. sodium thiosulphate in enough distilled water to make 1 liter, standardize the solution by titration with tenth-normal potassium dichromate V.S., potassium iodide and sulphuric acid (see below) and then dilute the solution, so that each mil corresponds with one mil of the dichromate solution. For details, including preservation of solutions, see U.S.P., p. 574. The pharmacopœia gives factors for thirteen chemicals assayed with tenth-normal sodium thiosulphate V.S. These include four elements—chlorine, bromine, iodine and ferric iron—the factor (grammes of chemical represented by 1 mil of the thiosulphate solution) is *the atomic weight divided by* 10,000; two compounds—copper sulphate (anhydrous and crystalline) —the factor for which is *the molecular weight divided by* 10,000; three—lead peroxide and sodium arsenate (anhydrous and crystalline)—the factor for which is *the molecular weight divided by* 20,000; one—chromium trioxide—the factor for which is *the molecular weight divided by* 30,000; two—potassium bromate and potassium dichromate—the factor for which is *the molecular weight divided by* 60,000 and lastly, one—the iodine content of thymol iodide—where a special value obtains.

TWO-HUNDREDTH-NORMAL SODIUM THIOSULPHATE VOLUMETRIC SOLUTION

$Na_2S_2O_3 + 5H_2O = 248.22$ 1.2411 Gm. in 1000 mils

Condensed Recipe.

Dilute 25 mils of tenth-normal sodium thiosulphate V.S. with enough distilled water to make a liter. This solution may be standardized with tenth-normal potassium dichromate V.S., potassium iodide and sulphuric acid. For details see U.S.P., p. 575.

The pharmacopœia gives the equivalent factor for elemental iodine and for iodine from thyroid glands. The figures are obviously one-twentieth the factors for the tenth-normal thiosulphate solution.

The arithmetic of the standardization of the tenth-normal thiosulphate solution is worthy of explanation.

On p. 892 (equation *f*) we find that chromium trioxide liberations iodine from potassium iodide. Potassium dichromate in acid solution does likewise, the equation being

$$\underset{294.20}{K_2Cr_2O_7} + 6KI + 6H_2SO_4 = Cr_2(SO_4)_3 + 3K_2SO_4 + 6H_2O + \underset{6 \times 126.9}{3I_2}$$

From this equation, we learn that

$$
\begin{aligned}
6 \times 126.9 \text{ Gm. I} &= 294.20 \text{ Gm. } K_2Cr_2O_7\\
126.9 \text{ Gm. I} &= 49.033 \text{ Gm. } K_2Cr_2O_7\\
12.69 \text{ Gm. I} &= 4.9033 \text{ Gm. } K_2Cr_2O_7.\\
\text{Hence } 1000 \text{ mil } n/10 \text{ iodine } (12.69 \text{ Gm. to the liter}) &= 4.9033 \text{ Gm. } K_2Cr_2O_7\\
1 \text{ mil } n/10 \text{ iodine} &= 0.0049033 \text{ Gm. } K_2Cr_2O_7.
\end{aligned}
$$

As 1 mil of tenth-normal thiosulphate V.S. is necessary to decolorize 1 mil of tenth-normal iodine V.S. and as 1 mil of tenth-normal dichromate V.S. contains 0.0049033 Gm. $K_2Cr_2O_7$, it follows that in the thiosulphate assay each mil of an exactly tenth-normal thiosulphate V.S. corresponds to 1 mil of tenth-normal dichromate V.S.

OFFICIAL DIRECT ASSAYS WITH TENTH-NORMAL SODIUM THIOSULPHATE V.S.

Iodine.—Accurately weigh about 0.5 Gm. powdered iodine and dissolve in an aqueous solution of potassium iodide. Dilute this with water and titrate with $n/10$ thiosulphate V.S. Indicator, starch paste. Strength, 99.5 per cent. I. Each mil $n/10$ $Na_2S_2O_3$, V.S. = 0.01269 Gm. I. Each Gm. U.S.P. iodine = 78.4 mils $Na_2S_2O_3$, V.S. For details see U.S.P., p. 229.

Like the foregoing are run.

Tincture of Iodine.—Five mils are taken (not weighed). This amount should take from 25.6 to 29.55 mils of V.S.

Compound Solution of Iodine.—Ten grammes are taken and are accurately weighed. Each gramme should take 3.8 to 4.0 mils of V.S.

OFFICIAL DIRECT ASSAY WITH TENTH-NORMAL IODINE V.S.

Sodium Thiosulphate.—Accurately weigh about 1 Gm. sodium thiosulphate, dissolve in distilled water and titrate with $n/10$ iodine V.S. Indicator, starch paste. Strength, 63.07 to 67.48 per cent. $Na_2S_2O_3$. Each mil $n/10$ iodine V.S. = 0.015814 Gm. $Na_2S_2O_3$. Each Gm. U.S.P. thiosulphate = 39.9 to 42.7 mils $n/10$ iodine V.S. For details see U.S.P., p. 401.

In the assays which follow the chemical or preparation is titrated directly with $n/10$ iodine V.S. The first two are given in detail, while last three are tabulated. For details concerning these see U.S.P.

Arsenic Trioxide.—Accurately weigh about 0.2 Gm. well-dried arsenic trioxide, dissolve in boiling water with the aid of sodium hydroxide solution. Carefully neutralize the arsenical solution; add 2 Gm. sodium bicarbonate and then titrate with $n/10$ I.V.S. Indicator, starch paste. Strength, at least 99.8 per cent. As_2O_3.

Each mil $n/10$ I.V.S. = 0.004948 gm. As_2O_3.

Each Gm. U.S.P. oxide = 210.7 mils $n/10$ I, V.S.

Solution of Arsenous Acid.—Accurately weigh about 20 mils of the solution dilute with water, add 2 Gm. sodium bicarbonate and titrate with $n/10$ iodine V.S. Indicator, starch paste. Strength, 0.975 to 1.025 per cent. As_2O_3.

Each mil $n/10$ iodine V.S. = 0.004948 Gm. As_2O_3.

Each Gm. U.S.P. solution = 1.97 to 2.07 mils $n/10$ iodine V.S. For details see U.S.P., p. 237.

Chemical (to all, sodium bicarbonate are added)	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator
Antimony and Potassium Tartrate.	0.5 Gm.	59.3 mils	Starch paste
Solution of Arsenic and Mercuric Iodide.	25.0 Gm.	0.42 to 0.46 mils	Starch paste
Solution of Potassium Arsenite.	20.0 Gm.	1.97 to 2.07 mils	Starch paste

The following are residual titrations, a definite excess of $n/10$ iodine

V.S. being employed and the surplus of free iodine remaining after the reduction reaction is then titrated with $n/10$ thiosulphate V.S. Taking as tangible example, the assay for exsiccated sodium sulphite given below, if we take exactly 0.3 gramme of that chemical, treat it with 50 mils of $n/10$ iodine V.S. and find on residual titration that the excess iodine requires 7.2 mils $n/10$ thiosulphate V.S. for decolorization, it means that $50-7.2$ or 42.8 mils $n/10$ iodine V.S. were used for reducing 0.3 gramme of the sulphite. Compare this result with the number of mils of $n/10$ iodine required to decolorize 1 gramme of sulphite.

Exsiccated Sodium Sulphite.—Accurately weigh about 0.3 Gm. exsiccated sulphite, and add it to 50 mils $n/10$ iodine V.S. After complete solution, titrate with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, at least 90 per cent. Na_2SO_3.

Each mil $n/10$ iodine V.S. $=0.006304$ Gm. $Na_2S_2O_3$.

Each Gm. U.S.P. sulphite $=142.8$ mils $n/10$ iodine V.S. For details see U.S.P., p. 400.

Mild Mercurous Chloride.—Accurately weigh about 1 Gm. well-dried chloride, and mix it with water and then with 50 mils $n/10$ iodine V.S. to which a solution of potassium iodide has been added. After complete solution has taken place, titrate with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, at least, 99.6 per cent. HgCl. Each mil $n/10$ iodine V.S. $=0.0236$ Gm. HgCl.

Each Gm. U.S.P. chloride $=42.2$ mils $n/10$ iodine V.S. For details, see U.S.P. p. 215

OFFICIAL OXIDATION ASSAYS WITH TENTH-NORMAL SODIUM THIOSULPHATE V.S.

Yellow Mercurous Iodide.—Like calomel. One gramme corresponds to 30.2 mils V.S.

Mercuric Salicylate.—Accurately weigh about 0.5 Gm. mercuric salicylate and dissolve it by digestion in a mixture of sulphuric and nitric acids. Dilute the solution with water, oxidize it with solution of hydrogen dioxide, then add diluted hypophosphorous acid, and sodium chloride. Collect and wash the resulting precipitate, then transfer it to a flask add 50 mils $n/10$ I.V.S. and an aqueous solution of potassium iodide. After the precipitate has dissolved, titrate the mixture with $n/10$ $Na_2S_2O_3$, V.S. Strength, 54 to 59.5 per cent. Hg. Each mil $n/10$ iodine S. $=0.0200$ Gm. Hg. Each Gm. U.S.P. salicylate $=26.9$ to 29.7 mils $n/10$ iodine V.S. For details see U.S.P., p. 219.

The following, while a residual reduction assay with $n/10$ iodine V.S. is so complex that an outline of the pharmacopœial text is given. It depends upon the precipitation of the sulphide as cadmium sulphide and the titration of this precipitate with $n/10$ iodine V.S.

Crude Calcium Sulphide.—Accurately weigh about 0.2 Gm. crude sulphide, mix it with distilled water and with 10 per cent. ammonium chloride solution. After shaking add 10 per cent. cadmium chloride solution and again shake. Then add acetic acid, warm on a water-bath for fifteen minutes, after which collect, and wash the resulting precipitate, which is then mixed with 50 mils of $n/10$ iodine V.S. and with hydrochloric acid and water. Finally titrate the excess of iodine with $n/10$ $Na_2S_2O_3$, V.S. Strength, at least 55 per cent. CaS.

Each mil $n/10$ I.V.S. $=0.003607$ Gm. CaS. Each Gm. U.S.P. sulphide $=152.5$ mils $n/10$ I.V.S. For details see U.S.P., p. 94.

The following assay is based upon the fact that acetone plus alkali plus iodine yields iodoform (p. 583). A known excess of $n/10$ iodine V.S. is employed in assay and the free iodine, remaining after the acetone has been converted into iodoform, is titrated with $n/10$ thiosulphate V.S.

Acetone.—Accurately weigh about 1 mil of acetone and dissolve in enough distilled water to make 1 liter. Treat 25 mils of this solution, with 25 mils of nKOH, V.S., then add 35 mils $n/10$ iodine V.S. and let stand. Then acidulate with nHCl, V.S. and titrate with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. A blank experiment must be run at the same time.

Each mil $n/10$ iodine V.S. consumed $=0.000967$ Gm. C_3H_6O. Each Gm. U.S.P. acetone $=1023$ mils $n/10$ iodine V.S.

Chlorinated Lime.—Weigh accurately in water, between 3 and 4 Gm. chlorinated lime, mix with water, take one-tenth of the mixture, add potassium iodide and acetic acid and then titrate the liberated iodine with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, at least 30 per cent. available chlorine.

Each mill $n/10$ $Na_2S_2O_3$, V.S. $=0.003546$ Gm. Cl.

Each Gm. U.S.P. lime $=84.6$ mils ($n/10$. $Na_2S_2O_3$, V.S. For details see U.S.P., p. 96.

Similar to this assay, treatment of the chemical with potassium iodide and acetic acid and final titration of the liberated iodine with $n/10$ thiosulphate V.S., are the ones outlined below. For details in each case see U.S.P.

Solution of Chlorinated Soda.—Use 7 grammes, accurately weighed. Each gramme corresponds to 7 mils thiosulphate V.S.

Copper Sulphate.—Use 1 gramme, accurately weighed. This amount corresponds to 41.83 mils thiosulphate V.S.

The assays which follow resemble the three just given except that the iodine is liberated from potassium iodide by treatment with hydrochloric acid instead of acetic acid.

Ferric Chloride.—Accurately weigh about 1 Gm. ferric chloride, dissolve in water, add hydrochloric acid and potassium iodide and after digestion at 40°C., titrate the liberated iodine with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, at least 20 per cent. Fe.

Each mil $n/10$ $Na_2S_2O_3=0.005584$ Gm. Fe.

Each Gm. U.S.P. chloride $=35.8$ mils $n/10$ $Na_2S_2O_3$, V.S. For details see U.S.P., p. 166.

Chemical	Approximate amount taking for weighing	Each gramme of chemical corresponds to mils of V.S.	Indicator
Solution of Ferric Chloride	2.0 Gm.	17.9 to 19.7 mils	Starch paste
Tincture of Ferric Chloride	5.0 mils	[Each mil = 5.1 to 5.9 mils V.S.]	Starch paste
Solution of Ferric Sulphate	1.5 Gm.	17.9 to 19.7 mils	Starch paste
Solution of Ferric Subsulphate	1.5 Gm.	23.3 to 25.1 mils	Starch paste
Iron and Ammonium Citrate	1.0 Gm.	28.6 to 32.2 mils	Starch paste
Iron and Quinine Citrate	1.0 Gm.	24.18 mils	Starch paste
Ferric Phosphate	1.0 Gm.	21.5 mils	Starch paste
Sodium Arsenate	0.5 Gm.	63.44 to 66.59 mils	Starch paste
Exsiccated Sodium Arsenate	0.3 Gm.	105.4 mils	Starch paste
Solution of Sodium Arsenate	30.0 Gm.	1.05 to 1.10 mils	Starch paste
Chromium Trioxide	0.15 Gm.	285.0 mils	Starch paste

For details concerning these see U.S.P.

Thymol Iodide.—Accurately weigh about 0.25 Gm. well-dried iodide, mix with about 3 Gm. anhydrous sodium carbonate and carbonize at red heat. Extract the residue with boiling distilled water, oxidize the warmed aqueous liquid with potassium permanganate solution, remove excess of permanganate by addition of alcohol, dilute with water and then filter. To exactly one-half of the filtrate, add diluted sulphuric acid and potassium iodide and then titrate the liberated iodine with $n/10$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, at least 43 per cent. iodine. Each mil $n/10$ $Na_2S_2O_3$, V.S. $=0.002115$ Gm. I. Each Gm. U.S.P. iodide $=203.3$ mils $n/10$ $Na_2S_2O_3$, V.S. For details see U.S.P., p. 442.

The object of the thymol iodide assay given above is first to convert the organic iodide into inorganic sodium iodide and then to oxidize this iodide to iodate by treatment with potassium permanganate. The resulting iodate is then treated with potassium iodide and sulphuric acid and the liberated iodine is then titrated with $n/10$ thiosulphate V.S.

OFFICIAL ASSAY WITH TWO-HUNDREDTH-NORMAL SODIUM THIOSULPHATE V.S.

Dried Thyroids.—Fuse 1 Gm. dried thyroids with a mixture of potassium carbonate, sodium carbonate and potassium nitrate. When the mixture is completely carbonized dissolve the residue in warmed distilled water. Then add solution of chlorinated soda and phosphoric acid, dilute with water and boil for one-half hour. After cooling the liquid, add to it potassium iodide and titrate the liberated iodine with $n/200$ $Na_2S_2O_3$, V.S. Indicator, starch paste. Strength, 0.17 to 0.23 per cent. iodine. Each mil $n/200$ $Na_2S_2O_3$, V.S. = 0.0000105 Gm. iodine. Each Gm. U.S.P. thyroids = 16.07 to 21.74 mils $n/200$ $Na_2S_2O_3$, V.S. For details see U.S.P., p. 443.

This assay, like the one for thymol iodide, is based upon the conversion of the organic into inorganic iodide, the oxidization of this to iodate, the treatment of this with potassium iodide and phosphoric acid; and the final titration of the liberated iodine with $n/200$ Thiosulphate V.S.

OXIDATION ASSAYS WITH TENTH-NORMAL POTASSIUM PERMANGANATE V. S.

We have already learned (p. 369) that potassium permanganate is a powerful oxidizer, and that a solution in the process of oxidation loses its characteristic purple or rose tint;—becomes decolorized. This phenomenon is employed in the volumetric estimation of oxidizable substances, known quantities of such substances being added to volumetric solution of potassium permanganate until a permanent pink tint ensues. In other cases advantage is taken of the fact that oxalic acid decolorizes potassium permanganate, and by mixing chemicals that react with oxalic acid with a known quantity of volumetric solution of that acid and titrating the excess of the acid with permanganate, the quantity of acid used in combining with the particular chemical can be deduced and the amount of the chemical calculated.

Before discussing the arithmetic of such calculation it may be well to give an outline of the official method of making decinormal permanganate solution:

TENTH-NORMAL POTASSIUM PERMANGANATE VOLUMETRIC SOLUTION

$KMnO_4 = 158.03$. 3.1606 Gm. in 1000 mils.

Condensed Recipe.

Mix 3.3 Gm. potassium permanganate U.S.P. in 1000 mils of distilled water and boil about 5 minutes. Plug the flask with absorbent cotton, let stand two days, and then decant the clear liquid, which is to be standardized and then dilute to exactly tenth-normal strength with a special distilled water, which has been treated with permanganate before being distilled. The pharmacopœia permits two methods of standardization of the tenth-normal permanganate V.S. In one, 0.3 Gm. well-dried sodium oxalate is dissolved in water, acidulated with sulphuric acid and then titrated with the permanganate V.S. until a permanent pink color is obtained. Each 0.0067 Gm. oxalate is equivalent to 1 mil of exactly $n/10$ $KMnO_4$, V.S. The second method consists in treating 25 mils of the permanganate V.S. with potassium iodide and sulphuric acid and then titrating the liberated iodine with tenth-normal sodium thiosulphate V.S. Each 25 mils $n/10$ $KMnO_4$, V.S. is equivalent to 25 mils $n/10$ $Na_2S_2O_3$, V.S. The pharmacopœia discusses the arithmetic of the standardization and the dilution of the permanganate V.S. (see also below) and directs how the finished solution should be kept. For details see U.S.P., p. 568.

The pharmacopœia also gives equivalent factors for 13 chemicals assayed with tenth-normal potassium permanganate V.S. In the case of four of these—ferrous carbonate, ferrous oxide, and ferrous sulphate (anhydrous and crystalline) the factor (grammes of chemical represented by 1 mil of tenth-normal permanganate V.S.) is *the molecular weight of the substance divided by* 10,000. With five—calcium oxide (as oxalate), hydrogen dioxide, oxalic acid, sodium nitrite and sodium oxalate—the factor is *the molecular weight of the chemical divided by* 20,000; with two—potassium chlorate and sodium chlorate—the factor is *the molecular weight of the substance divided by* 60,000. The remaining two are the elements; iron (in ferrous compounds and oxygen. The factor for the former is *the atomic weight divided by* 10,000, while that of the latter is *the atomic weight divided by* 20,000.

It will be seen from the above outline that the potassium permanganate solution is standardized by two methods—the one, the use of sodium oxalate; the other, by utilizing the property, possessed by permanganate in common with all other oxidizing agents, of liberating iodine from potassium iodide, estimating the amount of free iodine with sodium thiosulphate solution. As this latter process has just been explained (p. 892), we will proceed forthwith to the estimation of permanganate with sodium oxalate.

The reaction of this combination is as follows:

$$2KMnO_4 + 5Na_2C_2O_4 + 8H_2SO_4 = K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 10CO_2 + 8H_2O$$

2 × 158.03 5 × 134.0
or 316.06 or 670.0

It will be seen from this equation, that 670 Gm. sodium oxalate decolorize 316.06 Gm. potassium permanganate. The pharmacopœial monograph states that each mil of $n/10$ permanganate V.S. is equivalent to 0.0067 Gm. sodium oxalate. Then a liter (1000 mils) of $n/10$ permanganate V.S. is equivalent to 6.700 Gm. sodium oxalate. The equation just given shows that 670 Gm. sodium oxalate represents 316.06 Gm. permanganate; hence 6.7 Gm. oxalate is equivalent to 3.16 Gm. permanganate; the obvious conclusion therefore is that a liter of $n/10$ permanganate V.S. should contain 3.16 Gm. $KMnO_4$.

At first glance it seems erroneous to call the permanganate solution containing in a liter the number of grammes equivalent to one-fiftieth its molecular weight a decinormal solution, and it might here be stated that this conception is hard to comprehend unless we adopt the double formula of permanganate, $K_2Mn_2O_8$. If we take this double formula to express one molecule; if we appreciate that $K_2Mn_2O_8$ liberates 5 atoms oxygen in oxidation, viz.,

$$K_2Mn_2O_8 + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 3H_2O + O_5;$$

if we appreciate that this liberation of five atoms of oxygen really means combination of ten atoms of hydrogen, viz.,

$$10H + 5O = 5H_2O,$$

and, lastly, if we remember that the foundation of the arithmetic of volumetric testing is the quantity of substance that combines with or replaces one atom of hydrogen, we will see that the true normal solution of permanganate contains the amount with which one atom of hydrogen will combine—that is, $\frac{1}{10}$ of 316.06—and that the decinormal solution must contain in 1 liter $\frac{1}{100}$ of 316.06 Gm.

That this reasoning is sound is proved by the fact that a decinormal solution containing 3.16 Gm. permanganate to the liter combines with equal volumes of other decinormal solutions, such as $n/10$ oxalic acid V.S., and (in the second process of standardization) $n/10$ thiosulphate V.S.

Referring to the table given above, showing the equivalent values of 1 mil of $n/10$ permanganate, we find that while $n/10$ $K_2Mn_2O_8$ equals as many milligrammes of permanganate as its molecular weight divided by 100, 1 mil represents of the ferrous salts and hydrogen dioxide as many milligrammes as the molecular weight in each case divided by 10; while with the substances, calcium oxide, oxalic acid, and sodium nitrite, 1 mil of $n/10$ permanganate represents as many milligrammes as the molecular weight divided by 20. These can be best explained by a typical equation from each class:

(*a*) $10FeSO_47H_2O + K_2Mn_2O_8 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 15H_2O.$
$10 \times 278.02.$ 316.06
or 2780.2
We see that 316.06 Gm. $KMnO_4$ = 2780.2 Gm. $FeSO_47H_2O.$
3.1606 Gm. $KMnO_4$
or 1000 mils $n/10$ = 27.802 Gm. $FeSO_47H_2O.$
and that 1 mil $n/10$ $KMnO_4$ = 0.0278 Gm. $FeSO_47H_2O.$
(*b*) $5NaNO_2 + K_2Mn_2O_8 + 3H_2SO_4 = 5KNO_3 + 2MnSO_4 + K_2SO_4 + 3H_2O.$
5×69.10 316.06
or 345.05
We see that 316.06 Gm. $KMnO_4$ = 345.05 Gm. $NaNO_2$
3.1606 Gm. $KMnO_4$
or 1000 mils $n/10$ $KMnO_4$ = 3.4505 Gm. $NaNO_2.$
and that 1 mil $n/10$ $KMnO_4$ = 0.00345 Gm. $NaNO_2.$

That is, while chemicals of the type "*a*" in oxidizing take up one atom of oxygen to every two molecules of the oxidized chemical, chemicals of type "*b*" combine with oxygen in the proportion of one atom of oxygen to each molecule.

It will, of course, be remembered that one molecule $K_2Mn_2O_8$ yields five atoms of oxygen, and these five atoms combine with ten molecules of chemicals of type "*a*" and with five molecules of chemicals of type "*b*."

OFFICIAL ASSAYS MADE WITH TENTH-NORMAL PERMANGANATE V.S.

Solution of Hydrogen Dioxide.—Accurately weigh about 2 Gm. solution of hydrogen dioxide, dilute with water, acidulate with diluted sulphuric acid and then titrate with $n/10$ $KMnO_4$.V.S. Strength, at least 3 per cent. H_2O_2. Each mil $n/10$ $KMnO_4$ V.S. = 0.0017008 Gm. H_2O_2. Each Gm. U.S.P. solution = 17.6 mils $n/10$ $KMnO_4$, V.S. For details see U.S.P., p. 247.

This reaction differs from either equation given at the top of this page, inasmuch as both hydrogen dioxide and permanganate liberate oxygen, which passes off as gas, as shown in the following equation:

$$5H_2O_2 + K_2Mn_2O_8 + 3H_2SO_4 = 5O_2 + K_2SO_4 + 2MnSO_4 + 8H_2O.$$

Sodium perborate likewise liberates oxygen when treated with permanganate.

Sodium Perborate.—Like the assay for solution of hydrogen dioxide. One-quarter of a gramme is accurately weighed. One gramme corresponds to 112.5 mils $n/10$ permanganate V.S. For details see U.S.P., p. 394.

Ferrous Sulphate.—Accurately weigh about 1 Gm. ferrous sulphate, dissolve in 25 mils of diluted sulphuric acid and the titrate with $n/10$ $KMnO_4$, V.S. Strength, 54.36 to 57.07 per cent. $FeSO_4$. Each mil $n/10$ $KMnO_4$, V.S. = 0.015191 Gm. $FeSO_4$. Each Gm. U.S.P. sulphate = 35.78 to 37.57 mils $n/10$ $KMnO_4$, V.S. For details see U.S.P., p. 170.

Exsiccated Ferrous Sulphate.—Like ferrous sulphate, except that 0.8 Gm. is taken and is accurately weighed and that 1 Gm. corresponds to 52.7 mils V.S.

Reduced Iron.—Accurately weigh about 1 Gm. reduced iron, add 10 Gm. mercuric chloride and 50 mils of boiling distilled water, boil for 5 minutes, cool, filter, take exactly one-fifth of the fluid, acidulate with diluted sulphuric acid and then titrate with $n/10$ $KMnO_4$, V.S. Strength, at least 90 per cent. Fe. Each mil $n/10$ $KMnO_4$, V.S. = 0.005584 Gm. Fe. Each Gramme U.S.P. iron = 161.2 mils $n/10$ $KNMO_4$, V.S. For details see U.S.P., p. 173.

In this assay, the boiling of the iron with the mercuric chloride, converts all of the iron into ferrous chloride which is then assayed by titration with $n/10$ per manganate V.S.

The following are residual titrations, the chemical being treated with an excess of $n/10$ oxalic acid V.S. which combines with the metal found in the chemical. The surplus oxalic acid is then titrated with *n*/10 permanganate V.S.

Precipitated Calcium Carbonate.—Accurately weigh from 0.3 to 0.4 Gm. well-dried carbonate, mix with 10 mils of distilled water and 10 mils of diluted hydrochloric acid and boil to expel the evolved carbon dioxide. Then add 100 mils *n*/10 oxalic acid V.S., make alkaline with ammonia, let mixture stand and then filter. Acidulate the amount of filtrate representing exactly one-half of the original fluid with diluted sulphuric acid titrate the excess of oxalic acid with *n*/10 $KMnO_4$ V.S. and then calculate the amount of *n*/10 oxalic acid V.S. used by the lime salt. Strength, at least 98 per cent. $CaCO_3$.

Each mil *n*/10 $H_3C_2O_4$, V.S. = 0.005003 Gm. $CaCO_3$. Each Gramme U.S.P. carbonate = 195.9 mils *n*/10 $H_2C_2O_4$, V.S. For details see U.S.P., p. 90.

Calcium Oxide.—One gramme is dissolved in 20 mils diluted hydrochloric acid and enough water to make 100 mils one-fifth of the solution is then titrated as above. One gramme of lime = 338.9 mils V.S.

Prepared Chalk.—Assay like precipitated chalk. One gramme equals 193.9 mils, V.S.

Lead Oxide.—Accurately weigh about 0.4 Gm. freshly ignited oxide, dissolve in acetic acid and distilled water, and mix with 50 mils *n*/10 oxalic acid V.S. Then filter, acidulate the amount of filtrate representing exactly one-half of the original oxide, with diluted sulphuric acid, titrate the excess of oxalic acid with *n*/10 $KMnO_4$, V.S. and finally calculate the amount of *n*/10 oxalic acid, V.S. consumed by the oxide. Strength, at least 96 per cent. PbO. Each mil *n*/10 $H_2C_2O_4$, V.S. = 0.01115 Gm. PbO. Each gramme ignited oxide = 86.1 mils *n*/10 $H_2C_2O_4$, V.S. For details see U.S.P., p. 329.

Lead Acetate.—Accurately weigh about 5 Gm. lead acetate and dissolve in recently boiled distilled water. Mix one-tenth of this with 50 mils *n*/10 oxalic acid, V.S. let stand, then filter, acidulate the amount of filtrate representing one-twentieth of the amount of original acetate, titrate with *n*/10 $KMnO_4$, V.S. and then calculate a amount of *n*/10 oxalic acid V.S. consumed by the acetate. Strength, 85.31 to 89.75 per cent. $Pb(C_2H_3O_2)_2$.

Each mil *n*/10 $H_2C_2O_4$, V.S. = 0.016257 Gm. $Pb(C_2H_3O_2)_2$.

Each Gramme U.S.P. acetate = 52.5 to 55.1 mils *n*/10 $H_2C_2O_4$, V.S. For details see U.S.P., p. 328.

Solution of Lead Subacetate.—Like lead acetate, except that 1.5 grammes of the solution are added to the *n*/10 oxalic acid V.S. and filtrate, representing one-half of the original solution, is titrated with *n*/10 permanganate V.S. Each gramme of solution equals 17.4 mils V.S. For details see U.S.P., p. 250.

Precipitated Manganese Dioxide.—Accurately weigh about 0.2 Gm. precipitated dioxide, dissolve in a mixture of 50 mils *n*/10 oxalic acid V.S. and 3 mils sulphuric acid, warm, titrate with *n*/10 $KMnO_4$, V.S. and then calculate the amount of *n*/10 oxalic acid V.S. consumed by the dioxide. Strength, 80 per cent. MnO_2.

Each mil *n*/10 $H_2C_2O_4$, V.S. = 0.00434 Gm. MnO_2. Each Gm. U.S.P. oxide = 184 mils *n*/10 $H_2C_2O_4$, V.S. For details see U.S.P., p. 266.

Potassium Permanganate.—Accurately weigh about 0.15 Gm., dissolve in 25 mils water, add 1 mil sulphuric acid and 50 mils *n*/10 oxalic acid V.S. Titrate excess of oxalic acid with *n*/10 permanganate V.S. Each gramme permanganate equals 313.2 mils *n*/10 oxalic acid V.S. For details see U.S.P., p. 342.

The following is a residual titration in which an excess of *n*/10 permanganate V.S. is used to oxidize a nitrite to a nitrate: The surplus permanganate is then titrated with *n*/10 oxalic acid V.S.

Sodium Nitrite.—Accurately weigh about 1 Gm. well-dried nitrite, dissolve in distilled water, add one-tenth of the solution to a mixture of 50 mils *n*/10 $KMnO_4$, V.S. and 5 mils of sulphuric acid. Warm the liquid, let stand for five minutes, titrate excess of permanganate with *n*/10 oxalic acid V.S. and then calculate the amount of *n*/10 $KMnO_4$, V.S. consumed by the nitrite. Strength, at least 95 per cent. $NaNO_2$.

Each mil *n*/10 $KMnO_4$, V.S. = 0.00345 Gm. $NaNO_2$. Each Gm. dried nitrite = 275.3 mils *n*/10 $KMnO_4$, V.S. For details see U.S.P., p. 394.

The following assay represents an oxidation of ferrous sulphate to ferric sulphate with the chemical assayed. From the amount of ferrous sulphate that is converted into ferric sulphate, the quantity of chlorate used can be deduced.

Potassium Chlorate.—Accurately weigh about 0.1 Gm. potassium chlorate, dissolve in water and add to it an acidulated ferrous sulphate solution. Then boil the mixture in a flask fitted with a Bunsen valve; after the boiled mixture has cooled add manganese sulphate solution and then titrate with $n/10$ $KMnO_4$, V.S. At the same time, run a blank titration, thus estimating the strength of the ferrous sulphate solution used and then calculate the amount of ferrous sulphate consumed by the chlorate and of $n/10$ $KMnO_4$, V.S., that this represents. Strength at least 99 per cent. $KClO_3$.

Each mil of $n/10$ $KMnO_4$, V.S. $=0.0204$ Gm. $KClO_3$. Each Gm. U.S.P., chlorate $=484.7$ mils $n/10$ $KMnO_4$, V.S. For details see U.S.P., p. 335.

OXIDATION ASSAYS WITH TENTH-NORMAL POTASSIUM DICHROMATE V.S.

As the operation is so closely similar to assaying with potassium permanganate, and as only three official preparations are directed to be tested by this method, we need not take much time for its discussion.

All that is necessary to state is that the oxidation with dichromate is limited to ferrous salts and to the liberation of iodine from potassium iodide in standardizing sodium thiosulphate V.S. Further, that the oxidizing action of dichromate is that shown in the following typical equation:

$$K_2Cr_2O_7 + 4H_2SO_4 = K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + O_3.$$

In other words, while *two* molecules nitric acid in oxidation processes give three atoms of oxygen (see p. 399), one molecule dichromate gives three atoms of oxygen also. Hence when dichromate can be substituted for nitric acid in oxidations, one molecule does the work of two molecules of acid.

Since one molecule $K_2Cr_2O_7$ yields three atoms of oxygen, one molecule $K_2Cr_2O_7$ is the equivalent of six atoms of hydrogen; hence normal potassium dichromate solution would contain in 1000 mils as many grammes $K_2Cr_2O_7$ as the molecular weight (294.2) divided by 6: that is, 49.033 Gm. Therefore decinormal dichromate V.S. contains 4.9033 Gm. $K_2Cr_2O_7$ to the liter, as is shown in the pharmacopœial recipe given below.

TENTH-NORMAL POTASSIUM DICHROMATE VOLUMETRIC SOLUTION

$K_2Cr_2O_7=294.20$ 4.9033 Gm. in 1000 mils

Condensed Recipe.

Dissolve 4.9033 Gm. purified potassium dichromate in enough distilled water to make exactly 1000 mils. This solution is tenth-normal when used in oxidizing reactions and is therefore the equivalent of an equal volume of tenth-normal potassium permanganate V.S. or of tenth-normal sodium thiosulphate V.S., the cases of liberating iodine by oxidation. In direct titration, for neutralization of alkalies, however, when phenolphthalein is used as an indicator, its value is thirtieth-normal.

The pharmacopœia also describes its use in estimating ferrous salts and gives its equivalent factors, for five chemicals; these factors, of course, the same as the thiosulphate factors for the same chemicals. For details see U.S.P., p. 562.

OFFICIAL ASSAY MADE WITH TENTH-NORMAL POTASSIUM DICHROMATE V. S.

Saccharated Ferrous Carbonate.—Accurately weigh about 2 Gm. saccharated carbonate, dissolve in 15 mils of diluted sulphuric acid and dilute with distilled water. Then titrate with $n/10$ $KMnO_4$, V.S. Indicator, potassium ferricyanide.

Strength, at least 15 per cent. $FeCO_3$.

Each mil $n/10$ $K_2Cr_2O_7$, V.S. $=0.01158$ Gm. $FeCO_3$. Each Gm. saccharate carbonate $=13$ mils $n/10$ $K_2Cr_2O_7$, V.S. For details see U.S.P., p. 166.

The following preparations of ferrous carbonate are similarly assayed. For details see U.S.P.

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils of V.S.	Indication
Mass of Ferrous Carbonate....	1 Gm.	30.2 mils	Potassium ferricyanide.
Pills of Ferrous Carbonate....	3 pills	1 pill = 5.2 mils	Potassium ferricyanide.

VOLUMETRIC ASSAYS WITH SILVER NITRATE, POTASSIUM SULPHOCYANATE, AND SODIUM CHLORIDE

This class of assays is based either on the ability of silver nitrate to precipitate in definite proportions with the halogens, as shown in the following equation:

$$\underset{169.89}{AgNO_3} + \underset{58.46}{NaCl} = AgCl + NaNO_3,$$

or with potassium sulphocyanate, viz.,

$$\underset{169.89}{AgNO_3} + \underset{97.18}{KSCN} = AgSCN + KNO_3.$$

From the above equations and appended molecular weights we see that 169.89 Gm. $AgNO_3$ = 58.46 Gm. NaCl,
and that 169.89 Gm. $AgNO_3$ = 97.18 Gm. KSCN.

Since $n/10$ $AgNO_3$ V.S. contains 16.989 Gm. $AgNO_3$ to 1000 mils
and $n/10$ $AgNO_3$ V.S. contains 0.016989 Gm. $AgNO_3$ to 1 mil,
therefore 1 mil $n/10$ $AgNO_3$ V.S. = 0.005846 Gm. NaCl
and 1 mil $n/10$ $AgNO_3$ V.S. = 0.009718 Gm. KSCN.

As fully explained below, the indicator used when assaying halogens with silver nitrate is potassium chromate, it striking a red, permanent tint (silver chromate) only after the addition of just enough silver nitrate completely to precipitate the halogen. When testing with sulphocyanate, ferric alum is used as indicator, it forming red ferric sulphocyanate only after all the silver is precipitated.

The preparation of the volumetric solutions is given below:

TENTH-NORMAL SILVER NITRATE VOLUMETRIC SOLUTION

$AgNO_3$ = 169.89 16.989 Gm. in 1000 mils

Condensed Recipe.

Dissolve 10.798 grammes of pure silver in 30 mils (more if necessary) of nitric acid U.S.P. Evaporate the acid liquid on a water-bath, dry the residue in an oven and then dissolve in enough distilled water to make 1 liter. The pharmacopœia explains three methods of titration with tenth-normal silver nitrate V.S.

Soluble chlorides or bromides are titrated with the solution (using potassium chromate T.S. as indicator) the end of the reaction being indicated by the change in color of the solution from yellow to red (see above). This method is satisfactory only in neutral solutions.

Free halogen acids or their salts in acid solution are assayed by adding a known excess of the silver nitrate V.S. to a solution of the chemical, acidulating with nitric acid and then titrating with tenth-normal potassium sulphocyanate V.S., using ferric alum as indicator. The end of the reaction is shown by the formation of a red color in the solution (see above.) This assay is called the Volhard method.

Alkaline cyanides and hydrocyanic acid are assayed by titrating their solutions with fifth-normal silver nitrate V.S. until a permanent white precipitate is formed. For details see U.S.P., p. 571. The pharmacopœia gives equivalent factors for forty-three chemicals assayed with tenth-normal silver nitrate V.S. Three of these are the halogen elements bromine, chlorine and iodine and their equivalent factor (grammes of chemical represented by 1 mil of tenth-normal silver nitrate V.S.) is *the atomic weight of the element divided by* 10,000. Then there are three compounds—hydrocyanic acid, potassium cyanide and sodium cyanide; all by the precipitation method—the factor for which is *the molecular weight of the substance divided by* 5000. With eighteen chemicals—hydrocyanic acid (by the chromate method), ammonium bromide, ammonium chloride, ammonium iodide, hydriodic acid, hydrobromic acid, hydrochloric acid, lithium bromide, lithium chloride, potassium bromide, potassium chloride, potassium iodide, potassium nitrate, potassium sulphocyanate, sodium bromide, sodium chloride, sodium iodide and sodium nitrate—the factor is *the molecular weight of the substance divided by* 10,000; with eleven chemicals—allyl iso-thiocyanate, calcium bromide (crystalline and anhydrous) calcium chloride (crystalline and anhydrous), ferrous bromide, ferrous iodide, strontium bromide, strontium chloride, strontium iodide and zinc chloride—the factor is *the molecular weight of the substance divided by* 20,000; with six—arsenous iodide, phosphoric acid, potassium hypophosphite, sodium hypophosphite and sodium phosphate (crystalline and anhydrous)—the factor is *the molecular weight of the substance divided by* 30,000; with one, strontium salicylate, the factor is *the molecular weight divided by* 40,000; while with one, calcium hypophosphite, the factor is *the molecular weight divided by* 60,000.

HUNDREDTH-NORMAL SILVER NITRATE VOLUMETRIC SOLUTION

$AgNO_3 = 169.89$ 1.6989 Gm. in 1000 mils

Condensed Recipe.

Dilute 100 mils of tenth-normal silver nitrate V.S. with enough distilled water to make 1 liter. The pharmacopœia gives directions for keeping the solution and states that each mil of it is the equivalent of 0.0005846 Gm. sodium chloride. For details see U.S.P., p. 573.

TENTH-NORMAL SODIUM CHLORIDE VOLUMETRIC SOLUTION

$NaCl = 58.46$. 5.846 Gm. in 1000 mils.

Condensed Recipe.

Dissolve 5.846 Gm. of specially purified sodium chloride in enough distilled water to make exactly 1 liter.

The pharmacopœia points out that it corresponds, volume for volume, with tenth-normal silver nitrate V.S. and then gives the equivalent factor (grammes of chemical corresponding to 1 mil of tenth-normal sodium chloride V.S.) for silver, silver nitrate and silver oxide. The factor for silver is *the atomic weight divided by* 10,000 and for the salts is *the molecular weight of each divided by* 10,000. For details see U.S.P., p. 573.

TENTH-NORMAL POTASSIUM SULPHOCYANATE VOLUMETRIC SOLUTION

$KSCN = 97.18$. 9.718 Gm. in 1000 mils

Condensed Recipe.

Dissolve 11 Gm. crystalline potassium sulphocyanate in 1000 mils of distilled water. Standardize this by titrating a mixture of 10 mils of tenth-normal silver nitrate V.S., 3 mils of ferric alum solution and 3 mils of nitric acid with it, by the Volhard method. Then dilute the solution to exactly tenth-normal strength. The pharmacopœia explains the arithmetic of dilution. For details see U.S.P., p. 570. The pharmacopœia also gives the equivalent factor for seven chemicals assayed with tenth-normal potassium sulphocyanate V.S. Of these two are for silver compounds—the nitrate and the oxide—the factor (grammes of substance represented by 1 mil tenth-normal potassium sulphocyanate V.S.) being *the molecular weight of the substance divided by* 10,000; three are for mercuric compounds—the nitrate, the iodide and the oxide—the factor being *the molecular weight of the substance* divided by 20,000; while the other two are for the elements themselves. The factor of silver is *the atomic weight divided by* 10,000; that for mercury is *the atomic weight divided by* 20,000. For details see U.S.P., p. 571.

The following chemicals are assayed with $n/10$ silver nitrate V.S. by direct titration.

Diluted Hydrocyanic Acid.—Accurately weigh about 5 mils of the acid in a potassium hydroxide solution. Add 3 drops of potassium iodide solution and then titrate with $n/10$ $AgNO_3$, V.S. until a permanent precipitate results. Strength, 1.9 to 2.1 per cent. HCN.

Each mil $n/10$ $AgNO_3$, V.S. = 0.0054 Gm. HCN. Each Gm. U.S.P. acid = 3.5 to 3.89 mils $n/10$ $AgNO_3$, V.S. For details see U.S.P., p. 15.

Sodium Cyanide.—Like the foregoing, except that 0.45 Gm. of the cyanide, accurately weighed is dissolved in 25 mils water, and 4 mils ammonia water are added before the titration. Each gramme equals 96.9 mils $n/10$ $AgNO_3$, V.S.

This assay is based on the formation of a soluble double salt (Ag-CNKCN), which is decomposed the minute an excess of silver is added. Potassium iodide accentuates the reaction.

Oil of Bitter Almond (for HCN).—Prepare a solution of magnesium sulphate, add to it $n/2$ NaOH, V.S. and potassium chromate solution and then titrate with $n/10$ $AgNO_3$, V.S. to a permanent reddish tint. To this, add about 1 Gm. oil of bitter almond, accurately weighed (which bleaches the solution) and again titrate with $n/10$ $AgNO_3$. V.S. to a permanent red tint. Note the number of mils of silver solution required in the second titration and then calculate.

Each mil $n/10$ $AgNO_3$. V.S. = 0.0027 mil HCN. Each Gm. U.S.P. oil = 7.4 to 14.8 mils $n/10$ $AgNO_3$. V.S. For details see U.S.P., p. 285.

VOLUMETRIC ASSAYS WITH TENTH-NORMAL POTASSIUM SULPHOCYANATE V. S.

Silver Nitrate.—Accurately weigh about 0.8 Gm. well-dried nitrate, dissolve in distilled water, add nitric acid and ferric alum solution and titrate with $n/10$ KSCN. V.S. Strength, 99.8 per cent. $AgNO_3$.

Each mil $n/10$ KSCN, V.S. = 0.016989 Gm. $AgNO_3$. Each Gm. U.S.P. nitrate = 58.7 mils $n/10$ KSCN, V.S. For details see U.S.P., p. 61.

Moulded Silver Nitrate.—Accurately weigh about 0.8 Gm. moulded nitrate mixed with distilled water, filter off the silver nitrate solution, washing the residue and the filter with distilled water, add to the filtrate nitric acid and potassium chromate T.S. and then titrate with $n/10$ KSCN, V.S. Strength, at least 94.5 per cent. $AgNO_3$.

Each mil $n/10$ KSCN, V.S. = 0.01698 Gm. $AgNO_3$. Each Gm. moulded nitrate = 55.6 mils KSCN, V.S. For details see U.S.P., p. 62.

The following chemicals are similarly assayed, it being necessary however in each case to dissolve the compound in nitric acid in order to effect solution. For details see U.S.P.

Chemical	Approximate quantity taken for weighing	Each gramme of chemical corresponds to mils V.S.	Indicator
Silver Oxide	0.5 Gm.	86.0 mils	Ferric alum
Mercury	0.4 Gm.	99.2 mils	Ferric alum
Mercury with Chalk	1.0 Gm.	36.9 to 38.9 mils	Ferric alum
Yellow Mercuric Oxide	0.5 Gm.	91.9 mils	Ferric alum
Red Mercuric Oxide	0.5 Gm.	91.9 mils	Ferric alum

Solution of Arsenic and Mercuric Iodide (for mercuric iodide).—Accurately weigh about 25 grammes of the solution; add it to 5 mils of potassium hydroxide solution and 5 mils of formaldehyde solution, then warm until all of the mercuric salt is reduced to metallic mercury. Wash the metal with distilled water, then dissolve in nitric acid and then titrate with $n/10$ KSCN, V.S., using potassium chromate solution as indicator.

Strength, 0.95 to 1.05 per cent. HgI_2. Each mil $n/10$ KSCN, VS. = 0.02277 Gm. HgI_2. Each Gm. U.S.P. solution = 0.42 to 0.46 mil $n/10$ KSCN, V.S. For details see U.S.P., p. 238.

The object of the first part of the manipulation in the assay is to convert the mercury into a solution of mercuric nitrate. This then is directly titrated with $n/10$ sulphocyanate V.S., which forms an insoluble mercury sulphocyanate, even as it does an insoluble silver compound.

***Mass of Mercury.*—Accurately weigh about 0.5 Gm. mass of mercury, add a mixture of sulphuric and nitric acids and heat on a sand-bath until a clear colorless solution results. Then oxidise the solution with permanganate solution, decomposing excess of permanganate with oxalic acid solution. This solution is then titrated with $n/10$ KSCN, V.S., ferric alum being used as indicator. Strength, 32 to 34 per cent. Hg**

Each mil *n*/10 KSCN, V.S. = 0.01003 Gm. Hg. Each Gm. U.S.P. mass = 31.9 to 33.9 mils *n*/10 KSCN, V.S. For details see U.S.P., p. 268.

In this assay, the heating of the mass with sulphuric and nitric acids is to destroy the organic matter with which the mercury is admixed. The addition of potassium permanganate solution is to convert any possible mercurous salt into the mercuric form. The rest of the assay is a direct sulphocyanate titration.

VOLUMETRIC ASSAYS WITH TENTH-NORMAL SILVER NITRATE V.S. AND TENTH-NORMAL POTASSIUM SULPHOCYANATE V.S.

The present pharmacopœia (Part II, Test 5) provides special directions for the assay of bromides, chlorides or iodides.

Outline of Assay for Chlorides.—Accurately weigh about 0.2 gramme of the salt in distilled water, add 50 mils *n*/10 $AgNO_3$, V.S., acidulate with nitric acid, dilute with distilled water and filter. To the volume of filtrate representing exactly one-half of the original liquid, add ferric alum solution and titrate with *n*/10 KSCN,V.S. to a permanent reddish tint. From this figure, calculate the amount of *n*/10 $AgNO_3$, V.S. consumed by the amount of chloride employed.

For bromides, or iodides, from 0.4 to 0.5 Gm. salt is accurately weighed, is dissolved in distilled water, the solution is treated with 50 mils *n*/10 $AgNO_3$,V.S., with ferric alum solution and with nitric acid, after which the excess of silver nitrate is titrated with *n*/10 KSCN, V.S.

The pharmacopœia adds that 0.4 Gm. solution of zinc chloride and 0.7 Gm. strontium bromide or iodides are to be used in the above assay. For details see U.S.P., p. 588.

By this method the following chemicals are tested:

Potassium Bromide.—This is to be assayed as directed in the pharmacopœia under the assay for bromides. The salt must contain, at least, 98.5 per cent. KBr.

Each mil *n*/10 $AgNO_3$,V.S. = 0.0119 Gm. KBr. Each Gm. U.S.P. bromide = 82.8 to 84.8 mils *n*/10 $AgNO_3$, V.S.

In this assay an excess of volumetric solution of silver bromide is added, and after precipitation of silver bromide, the silver still remaining in solution is titrated with potassium sulphocyanate. The calculations whereby the figures given in the assay are obtained are as follows:

By reference to the equivalent tables given on p. 572 we find:

1 mil *n*/10 $AgNO_3$,V.S. = 0.011902 Gm. KBr, or reversed, 0.011902 Gm. KBr takes 1 mil *n*/10 $AgNO_3$,V.S. Then 1.00 Gm. KBr takes $\frac{100,000}{11,902} \times 1$ mil *n*/10 $AgNO_3$,V.S. or 1.00 Gm. KBr takes about 84 mils *n*/10 $AgNO_3$,V.S.

The other chlorides, bromides and iodides may be titrated as follows:

Chemical	Amount of chemical taken to be weighed	Each gramme of chemical corresponds to mils V.S.
Potassium Iodide	0.4 Gm.	59.6 to 60.98 mils
Sodium Bromide	0.4 Gm.	95.7 mils
Sodium Chloride	0.25 Gm.	169.3 mils
Sodium Iodide	0.5 Gm.	66.3 to 67.7 mils
Lithium Bromide	0.35 Gm.	79.9 mils
Ammonium Bromide	0.40 Gm.	100.5 to 103.4 mils
Ammonium Chloride	0.2 Gm.	186.0 mils
Ammonium Iodide	0.5 Gm.	68.2 to 70.1 mils
Calcium Bromide	0.4 Gm.	84.0 mils
Calcium Chloride	0.3 Gm.	135.0 mils
Strontium Bromide	0.8 Gm.	55.1 to 56.6 mils
Strontium Iodide	1.0 Gm.	44.0 mils
Zinc Chloride	0.3 Gm.	139.4 mils
Solution of Zinc Chloride	0.6 Gm.	71.9 to 74.8 mils
Arsenic Iodide	0.5 Gm.	65.17 mils

For details see U.S.P.

Potassium Nitrate.—Accurately weigh about 0.4 Gm. well-dried nitrate, dissolve in 10 mils of hydrochloric acid, evaporate the solution to dryness on a water-bath; repeat treatment with hydrochloric acid and evaporation, then dissolve in water and assay for chlorides, as above. The pharmacopœia directs that another sample of nitrate be assayed for chlorides and this be considered in the calculations of the assay for nitrate.

Each mil $n/10$ $AgNO_3$, V.S. = 0.01011 Gm. KNO_3. Each Gm. U.S.P. nitrate = at least 97.9 mils $n/10$ $AgNO_3$, V.S. For details see U.S.P., p. 341.

In the foregoing assay, the nitrate is heated with hydrochloric acid and the resulting chloride is then $n/10$ silver nitrate V.S. and $n/10$ sulphocyanate V.S.

Similar residual assays are provided for the following official chemicals:

Diluted Hydriodic Acid.—Accurately weigh about 5 mils of diluted hydriodic acid, dilute with distilled water, add 50 mils $n/10$ $AgNO_3$, V.S. and shake. Acidulate with nitric acid, add ferric alum solution and then titrate the excess of silver nitrate with $n/10$ KSCN, V.S. From the amount used, calculate the amount of $n/10$ $AgNO_3$, V.S. consumed by the hydriodic acid. Strength, 9.5 to 10.5 per cent. HI.

Each mil $n/10$ $AgNO_3$, V.S. = 0.012793 Gm. HI. Each Gm. U.S.P. acid = 7.4 to 8.2 mils $n/10$ $AgNO_3$, V.S. For details see U.S.P., p. 12.

Syrup of Hydriodic Acid.—Like the foregoing except take exactly 25 mils of the syrup, add 40 mils of $n/10$ $AgNO_3$ and proceed with residual titration. Each 100 mils of syrup takes 101.6 to 113.3 mils V.S. For details see U.S.P. p , 427.

Syrup of Ferrous Iodide.—Exactly as in assay of diluted hydriodic acid, except that 10 Gm. syrup are accurately weighed. Each gramme equals 3.07 to 3.4 mils V.S. For details see U.S.P., p. 429.

Phosphoric Acid.—Accurately weigh about 1 Gm. phosphoric acid and dilute with distilled water to 100 mils. Take 10 mils of this dilution, neutralize it with sodium hydroxide solution, add 50 mils $n/10$ $AgNO_3$, V.S., then zinc oxide and then enough distilled water to make 100 mils. Filter, add to 50 mils of filtrate, nitric acid and ferric alum solution and then titrate the excess of silver nitrate with $n/10$ KSCN, V.S. From the amount of sulphocyanate V.S. used calculate the amount of $n/10$ $AgNO_3$, V.S. consumed by the phosphoric acid. Strength, 85 to 88 per cent. H_3PO_4.

Each mil $n/10$ $AgNO_3$, V.S. = 0.00326 Gm. H_3PO_4. Each Gm. U.S.P. acid = 260 to 269.2 mils $n/10$ $AgNO_3$, V.S. For details see U.S.P., p. 21.

The following chemicals are assayed like phosphoric acid. For details see U.S.P.

Chemical	Amount of chemicals taken to be weighed	Each gramme of chemical corresponds to mils V.S.
Diluted Phosphoric Acid	1 mil	29.0 to 31.2 mils
Sodium Phosphate	0.4 gm.	39.2 to 44.0 mils
Sodium Phosphate Exsiccated	0.2 gm.	207.0 mils
Calcium Hypophosphite	0.75 gm.	345.5 mils
Potassium Hypophosphite	1.0 gm.	282.3 mils
Sodium Hypophosphite	0.4 gm.	39.25 to 44.0 mils

Volatile Oil of Mustard.—Accurately weigh about 4 mils of the oil, and dissolve it in enough alcohol to make 100 mils. Mix 5 mils of this solution with 30 mils $n/10$ $AgNO_3$, V.S. and with ammonia water, heat in flask provided with a reflux condenser on a water-bath for one hour, then cool, dilute with distilled water, filter and titrate one-half of the filtrate (after adding nitric acid and ferric alum solution) with $n/10$ KSCN, V.S. From the amount of this solution used calculate the amount of silver nitrate consumed by the oil. Strength, at least, 92 per cent. allyl iso-thiocyanate.

Each mil $n/10$ $AgNO_3$, V.S. = 0.00495 Gm. allyl iso-thiocyanate. For details see U.S.P., p. 302.

CHAPTER LV

ASSAYS OF ORGANIC SUBSTANCES

PHARMACEUTIC ASSAYING

ASIDE from the volumetric estimation of organic acids described on p. 890 under Alkalimetry, there are several forms of volumetric assays peculiar to organic substances. These include estimation of saponification number and iodine absorption number of oils and fats; the acid number of resins; that modification of acidimetry applied in alkaloidal assays, as well as the special assay of sugars with Fehling's solution and of phenol with Koppeschaar's solution. These will be considered in this chapter.

ALKALOIDAL ASSAYS

OFFICIAL ASSAYS IN WHICH THE ALKALOID OR PRINCIPLE IS WEIGHED

As already outlined on p. 859, the official assays for alkaloids naturally fall into two groups—the isolation of the alkaloid and the estimation of the isolated alkaloid either by direct weighing or by estimation by titration with decinormal or centinormal acid (or indirectly by titrating excess of acid with volumetric alkali solution). As already mentioned, the alkaloid is isolated by extracting the drug with aqueous (either plain or acidulated) media, the alkaloid set free by addition of alkali, and the freed alkaloid separated by "shaking out" with a solvent immiscible with water. The pharmacopœial details of the "shaking out" process are outlined below.

The pharmacopœia (p. 593) gives minute general directions for conducting alkaloidal assays and the monograph should be carefully read by all students. It discusses the "shaking out" process with suggestions as to the separation of the chloroformic or the ethereal layer. The determination as to whether the aqueous layer has been freed from alkaloids; the care required in the evaporation of the chloroformic or ethereal extract; the best way of avoiding emulsions in the "shaking out" process; and the choice of indicators, when the alkaloid is titrated.

Outline of Assay of Cinchona.—Extract 5 Gm. powdered cinchona with a mixture of chloroform, ether, ammonia water and water. From this mixture decant the amount of clear fluid representing 4 Gm. drug. Filter into a separator and shake out with weak sulphuric acid. Put the acid solution in another separator, make alkaline with ammonia water, shake out with chloroform, evaporate the chloroformic extracts and after purifying by dissolving in alcohol and again evaporating to dryness, at 100°C., weigh the alkaloidal residue. For details see U.S.P., p. 112.

Outline of Assay of Fluidextract of Cinchona.—Distribute 5 mils of the fluidextract over purified sawdust and after evaporating to dryness at 80°C., proceed to assay as in the case of cinchona. For details see U.S.P., p. 181.

Outline of Assay of Tincture of Cinchona.—Concentrate 25 mils of the tincture by heating on a water-bath to 15 mils, mix with purified sawdust, dry at 80°C. and then proceed as in the cinchona assay.

The Assay of Compound Tincture of Cinchona is like that of the simple tincture except that 50 mils of the compound tincture are taken.

From the above assays it is seen that the process of manipulation is tedious and intricate. It can be noted, however, that there are really three steps in the process: the *extraction* of the drug with ether and chloroform; the *shaking out*, first, with normal sulphuric acid and water, then (after rendering alkaline) with chloroform and lastly, evaporation of solution and *weighing* of alkaloids. The "separator" mentioned in the assay means one of the separatory funnels pictured on p. 141.

Outline of Assay of Colchicum Seed.—Digest 15 Gm. powdered seed, with solution of lead subacetate and distilled water, at 60° to 70°C. for three hours, then cool, dilutewith distilled water. Filter, precipitate the lead from the filtrate with sodium phosphate and again filter. Of the second filtrate, put the amount representing 5 Gm. colchicum seed into a separator, shake out with chloroform and evaporate the chloroformic extracts to dryness. Purify by dissolving in alcohol and then evaporate again and then weigh the alkaloidal residue. Treat this residue with $n/20$ H_2SO_4, V.S. collect the portion insoluble in this acid upon a pledget of absorbent cotton and after washing and partially drying it. Then dissolve this residue in alcohol followed by ether, evaporate the alcohol-ether filtrate, weigh what matter is left after the evaporation, and subtract this weight from the weight of the original alkaloidal residue. The difference represents the amount of colchicine in 5 Gm. colchicum seed. For details see U.S.P., p. 120.

The Assay of Colchicum Corm is like that of the seed; starting with 15 grammes of the corm.

The Assay of Extract of Colchicum Corm is like that of the seed, except that 6 Gm. extract are taken and the weight of the purified residue shows the amount of colchicine in 2 Gm. extract.

The Assay of Fluidextract of Colchicum Seed is like that of the seed, except that 15 mils of the fluidextract are taken and the treatment with solution of lead subacetate is slightly different. For details see U.S.P., p. 182.

The Assay of Tincture of Colchicum Seed is like that of the seed, except that 150 mils of the tincture are evaporated on a water-bath to about 20 mils and that the treatment with solution of lead subacetate and water is slightly different. For details see U.S.P., p. 453.

Outline of Assay of Cantharides.—Extract 15 Gm: powdered cantharides with a mixture of benzene, purified petroleum benzin and hydrochloric acid, macerating for twelve hours and then digesting for three hours at 40°C. Decant the amount of clear fluid representing 10 Gm. cantharides, evaporate spontaneously to about 5 mils, add 5 mils of chloroform and evaporate to dryness spontaneously in a warm place. Purify the crystalline residue by washing with a saturated solution of cantharidin in dehydrated alcohol and purified petroleum benzin, until it is free from fat and color. Then dissolve the crystalline residue in chloroform, evaporate the chloroform with the aid of a blast of air, dry the crystals at 60°C. and weigh. The weight represents the amount of cantharidin in 10 Gm. cantharides. For details see U.S.P., p. 100.

Outline of Assay of Guarana.—Extract 6 Gm. powdered guarana, with a mixture of chloroform and ammonia water by maceration with agitation. Filter the mixture and taking the amount of filtrate representing 5 Gm. guarana, evaporate it to dryness, dissolve the evaporated residue in weak sulphuric acid, transfer the acid solution to a separator, make alkaline with ammonia water and shake out with several portions of chloroform. Evaporate the chloroformic extracts at 80°C. and weigh. The weight represents the caffeine in 5 Gm. guarana. For details see U.S.P., p. 212.

Outline of Assay of Fluidextract of Guarana.—Mix 5 mils of the fluidextract with 1 mil of ammonia water in a separator, shake out with chloroform, evaporate the chloroformic extract, then dissolve the residue in distilled water and filter. Transfer the aqueous filtrate to a separator, shake out with chloroform and evaporate the chloroformic extracts to constant weight at 80°C. For details see U.S.P., p. 186.

Jalap is assayed by extraction and weighing, but as the assay is a purely physical process, involving no chemical change and no "shaking out," it is placed under the discussion of the drug on p. 646.

Scammony Root is assayed just as is jalap.

Asafetida is assayed for its alcohol solubility. The method is given on p. 777.

OFFICIAL ASSAYS IN WHICH THE ALKALOID IS TITRATED

Outline of Assay of Belladonna Root.—Extract 15 Gm. powdered belladonna root with a mixture of chloroform, ether and ammonia water. After proper maceration, decant the amount of clear fluid representing 10 Gm. drug, transfer it to a separator and shake out with weak sulphuric acid. Put the acid extracts in another separator, make alkaline with ammonia water and shake out with chloroform. Evaporate the chloroformic extracts to dryness, dissolve the residue in exactly 5 mils $n/10$ H_2SO_4, V.S. and titrate excess of acid with $n/50$ KOH, V.S. Indicator, cochineal T.S. Each mil $n/10$ H_2SO_4, V.S. = 0.02892 Gm. alkaloids. For details see U.S.P., p. 73.

Outline of Assay of Fluidextract of Belladonna Root.—Mix 10 mils of the fluidextract with distilled water and ammonia water in a separator. Shake out with several portions of chloroform, transfer the chloroformic extracts to another separator and shake out with weak sulphuric acid. Transfer the acid extracts to another separator, make alkaline with ammonia water and shake out with chloroform. Evaporate the chloroformic extracts to dryness, dissolve the residue in exactly 5 mils $n/10$ H_2SO_4 V.S. and titrate excess of acid with $n/50$ KOH, V.S. Indicator, cochineal T.S.

Each mil $n/10$ H_2SO_4, V.S. $=0.02892$ Gm. alkaloids. For details see U.S.P., p. 178.

The Assay of Belladonna Leaves is like that of belladonna root, except slight changes the amount of water used and the fact that the residue before titration is treated with ether. For details see U.S.P., p. 72.

Outline of Assay of Pilular Extract of Belladonna Leaves.—Dissolve 2 Gm. extract in 10 mils of diluted alcohol, transfer to a separator, make alkaline with ammonia water and proceed as in the assay of the fluidextract. For minor variations and other details see U.S.P., p. 145.

Outline of Assay of Powdered Extract of Belladonna Leaves.—Mix 3 Gm. powdered extract with washed sand, macerate with a mixture of chloroform, ether and ammonia water, decant an amount of the clear fluid representing 2 Gm. extract and proceed as in the assay of belladonna root. For minor variations and other details see U.S.P., p. 146.

Outline of Assay of Tincture of Belladonna Leaves.—Evaporate 100 mils of the tincture in a water-bath to about 10 mils and proceed as in the assay of fluidextract of belladonna root. For minor variations and other details see U.S.P., p. 448.

Outline of Assay of Belladonna Plaster.—Extract 10 Gm. belladonna plaster in strips with chloroform, alcohol and some ammonia water. After the mass has separated from the cloth base, dry the cloth, weigh it and subtract its weight from the weight of the spread plaster. Then pour the chloroform-alcohol solution into a separator, mix with distilled water, draw off the chloroform layer, transfer it to another separator and rinse it out with more water. Combine with aqueous extracts, shake them out with more chloroform, which is to be mixed with the original chloroform extract. The mixed chloroform solution is then shaken out several times with weak sulphuric acid, the acid extracts are put with another separator, are made alkaline with ammonia water and are shaken out with chloroform. The filtered chloroform extracts are evaporated to dryness, the residue is dissolved in exactly 5 mils of $n/10$ H_2SO_4, V.S. and the excess of acid is titrated with $n/50$ KOH, V.S. Indicator, cochineal T.S. For details see U.S.P., p. 134.

The Assay of Aconite is like that for belladonna root, except that ether is used as the immiscible solvent. For details see U.S.P., p. 30.

The Assay for Extract of Aconite is like that of belladonna root except that the extract is mixed with washed sand, then macerated with ether and ammonia water and the amount of clear fluid representing 2 Gm. extract is decanted and used in the process. Another difference is the fact that ether is used as the immiscible solvent. See U.S.P., p. 144.

The Assay for Fluidextract of Aconite is like that of belladonna root, except that ether is used as the immiscible solvent and that 15 mils of the fluidextract are mixed with purified sawdust and dried prior to maceration with ether and ammonia water. For details see U.S.P., p. 177.

The Assay for Tincture of Aconite is like that of the fluidextract except that 150 mils of the tincture are concentrated to about 20 mils, mixed with purified sawdust dried and then macerated with ether and ammonia water. For details see U.S.P., p. 445.

The Assay of Hydrastis is like that of belladonna root, except that ether is used as the immiscible solvent and that the amount of ethereal solution representing 5 Gm. drug is taken to complete the assay. For other minor details see U.S.P., p. 224.

The Assay of Extract of Hydrastis is like that of belladonna root, except that the extract is mixed with washed sand, is macerated with ether and ammonia water and that an amount of the clear fluid representing 2 Gm. extract is decanted and used. Another difference is the use of ether as the immiscible solvent. For details see U.S.P., p. 154.

The Assay of Fluidextract of Hydrastis is like that of fluidextract of belladonna root, except that 5 mils of the fluidextract are used and that the immiscible solvent is ether. For details see U.S.P., p. 186.

The Assay for Glycerite of Hydrastis resembles that of the fluidextract. For minor differences and for details see U.S.P., p. 205.

The Assay for Tincture of Hydrastis is like that of the fluidextract except that 50 mils of tincture are taken and are concentrated to about 10 mils before proceeding with the assay. For details see U.S.P., p. 456.

The Assay of Hyoscyamus is like that of belladonna root. For minor differences and for details see U.S.P., p. 225.

The Assay of Extract of Hyoscyamus is like that of pilular extract of belladonna leaves except that 5 Gm. extract are used. For details see U.S.P., p. 155.

The Assay of Fluidextract of Hyoscyamus is like that of fluidextract of belladonna root except that 25 mils of the fluidextract are used. For minor differences and for details see U.S.P., p. 187.

The Assay of Tincture of Hyoscyamus is like that of fluidextract of belladonna root except that 250 mils of the tincture are concentrated to 10 mils before proceeding with the assay. For other minor differences see U.S.P., p. 457.

The Assay of Ipecac is like that of belladonna root except that ether is used as the immiscible solvent and that the amount of ethereal extract representing 5 Gm. drug is used in the assay. For other minor differences see U.S.P., p. 230.

Outline of Assay of Fluidextract of Ipecac.—Mix 10 mils of the fluidextract with purified sawdust, dry at 80°C., and macerate with a mixture of ether and ammonia water. Then decant the amount of clear fluid representing 5 mils of the fluidextract, put it in a separator and shake out with weak sulphuric acid. Put the acid solution in another separator, make alkaline with ammonia water and shake out with ether. Evaporate the ethereal extracts to dryness, dissolve residue in exactly 10 mils $n/10$ H_2SO_4, V.S. and titrate excess of acid with $n/50$ KOH, V.S. Indicator, cochineal T.S. For details see U.S.P., p. 188.

The Assay of Nux Vomica is like that of belladonna root, except minor details, such as the amount of ammonia water and of $n/10$ H_2SO_4, V.S. used and the time of shaking and maceration. See U.S.P., p. 281.

The Assay of Extract of Nux Vomica is like that of belladonna root, except that the extract is mixed with washed sand, is macerated with a mixture of ether, chloroform and ammonia water and that the amount of clear fluid, representing 2 Gm. extract, is decanted and assayed. Then the amount of $n/10$ H_2SO_4, V.S., used to dissolve the residue is 10 mils. For details see U.S.P., p. 157.

The Assay of Fluidextract of Nux Vomica is like that of fluidextract of belladonna root, except that 10 mils $n/10$ H_2SO_4, V.S. are used to dissolve the residue. For details see U.S.P., p. 189.

The Assay of Tincture of Nux Vomica is like that of fluidextract of belladonna root, except that 100 mils of the tincture are concentrated to about 10 mils, before proceeding with the assay . For other minor differences see U.S.P., p. 461.

Outline of Assay of Opium.—Carefully extract 8 Gm. opium with distilled water. Evaporate the aqueous filtrate and washings on a water-bath to about 40 Gm. and then dilute with enough distilled water to make exactly 50 mils of fluid. Mix this with pure, freshly slaked lime, dilute with water, filter and macerate the amount of filtrate representing 4 Gm. opium with a mixture of alcohol, ether and ammonium chloride. Wash the resulting crystals of morphine, first with ether, then with a saturated, aqueous solution of morphine, dissolve them in exactly 20 mils $n/10$ H_2SO_4, V.S. and then titrate excess of acid with $n/50$ KOH, V.S. Indicator, cochineal T.S. For details see U.S.P., p. 306.

Powdered Opium, Deodorized Opium and Granulated Opium are assayed just as is opium.

The Assay of Extract of Opium is like that of opium, except that in starting, 4 Gm. extract are dissolved in distilled water, filtered and the filter is washed with enough water to make 50 mils. This filtrate is then treated with lime. For details see U.S.P. p. 158.

The Assay of Tincture of Opium is like that for opium except that in starting 80 mils of the tincture is heated on a water-bath until all of the alcohol is removed. The residue is then diluted with water and treated with lime. For details see U.S.P., p. 462.

Tincture of Deodorized Opium is assayed just as is the simple tincture.

Outline of Assay of Physostigma.—Macerate 15 Gm. physostigma with a mixture of ether, distilled water and sodium bicarbonate, decant off the amount of clear liquid representing 10 Gm. drug. Add to this filtered ethereal solution 20 mils $n/10$ H_2SO_4, V.S. and then evaporate the ether. Pour off the acid liquid from the resin and fat into a separator and treat the resin and fat with more ether and $n/10$ H_2SO_4 V.S. and continue doing this until all of the alkaloids have been dissolved by the acid. Then make the acid solution, alkaline with sodium bicarbonate solution and shake out with ether. Wash the ethereal extract with distilled water, then evaporate it to dryness. Dissolve the residue in exactly 5 mils $n/10$ H_2SO_4, V.S. and titrate the excess of acid with $n/50$ KOH, V.S. Indicator, cochineal T.S. For details see U.S.P., p. 320.

The Assay of Extract of Physostigma is like that of physostigma, except that, in starting, 3 Gm. extract are mixed with washed sand and then mixed with ether, distilled water and sodium bicarbonate. For details see U.S.P., p. 160.

The Assay of Tincture of Physostigma is like that of physostigma, except that in starting, 150 mils of the tincture are concentrated to about 20 mils, the evaporated liquid is mixed with purified sawdust and dried and the dry mixture is then treated with ether, distilled water and sodium bicarbonate. For details see U.S.P., p. 464.

The Assay of Pilocarpus is like that of belladonna; 15 Gm. drug being used. For minor differences see U.S.P., p. 323.

The Assay of Fluidextract of Pilocarpus is like that of belladonna root, except that, in starting, 15 mils of the fluidextract are mixed with purified sawdust and the mixture is evaporated to dryness, before macerating with chloroform, ether and ammonia water. For other minor differences see U.S.P., p. 190.

The Assay of Stramonium is like that of belladonna root; 15 Gm. drug being used. The main difference is the treatment of the alkaloidal residue with ether, prior to titration. For details see U.S.P., p. 411.

The Assay of Powdered Extract of Stramonium is exactly like that of the powdered extract of belladonna.

The Assay of Pilular Extract of Stramonium is exactly like that of the pilular extract of belladonna.

The Assay of Tincture of Stramonium is like that of fluidextract of belladonna root, except that, in starting 100 mils of the tincture are concentrated to about 10 mils, before mixing with distilled water and ammonia water. For other minor differences see U.S.P., p. 467.

It might be well to give brief consideration to the arithmetic of alkaloidal titration.

Taking aconite as a type, it will be well to notice that it is stated in the assay of the drug the fluidextract and the tincture that each mil of *n*/10 H_2SO_4, V.S. corresponds to 64.539 milligrammes of aconitine. This figure it will be noted, is an exact decimal fraction of the molecular weight of aconitine, 645.39. That 1 mil *n*/10 H_2SO_4, V.S. equals 64.539 milligrammes can be proven by following the regular process of finding the equivalent value for that amount of volumetric solution. Repeating the process in this special case:

$$\underset{\substack{\text{One molecule}\\ \text{sulphuric acid.}\\ 98.09}}{H_2SO_4} + \underset{\substack{\text{Two molecules}\\ \text{aconitine.,}\\ 2\times 645.39}}{2C_{34}H_{47}NO_{11}} = \underset{\text{Aconitine sulphate.}}{(C_{34}H_{47}NO_{11})_2H_2SO_4}$$

Remembering (p. 884) that 1 mil tenth-normal $H_2SO_4 = 0.0049045$ Gm. absolute H_2SO_4, we see—

That 98.07 Gm. absolute H_2SO_4 that $= 2 \times 645.39$ Gm. aconitine,
49.045 Gm. absolute H_2SO_4 $= 645.39$ Gm. aconitine.
And that 0.0049045 Gm. absolute H_2SO_4 $= \frac{1}{10,000} \times 645.39$ Gm. aconitine, or
0.064539 Gm. aconitine or 64.539 milligrammes of aconitine.

This method of reasoning applies to all of this class of assays; the definite numeric factor being the molecular weight of the appropriate alkaloid divided by 10,000; the amount of alkaloid (expressed in grammes) neutralized by one mil of tenth-normal sulphuric acid V.S.

SPECIAL ACIDIMETRIC ASSAYS OF VOLATILE OILS

Aldehydes and volatile oils containing them can be indirectly assayed by acidimetric processes. The present pharmacopœia provides assays of this character for benzaldehyde and for six volatile oils.

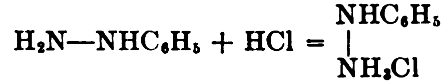
Outline of Assay of Benzaldehyde.—Titrate 25 mils of a freshly prepared alcoholic solution of phenylhydrazine with *n*/2 HCl, V.S., using methyl orange T.S. as an

indicator. Mix about 1 Gm. benzaldehyde, accurately weighed, with another 25 mils of the same phenylhydrazine solution, let stand for thirty minutes, add methyl orange T.S. and then add a known excess of *n*/2 HCl, V.S. Filter the mixture and then titrate the filtrate and washings with *n*/2 KOH, V.S. From the amount of alkali V.S. required, calculate the amount of *n*/2 HCl, V.S. consumed by the excess of phenylhydrazine and from this, the amount of benzaldehyde may be deduced. The factor given by the pharmacopœia is 0.053. (See below.) For details see U.S.P., p. 74.

This assay is based upon the following principles: Phenylhydrazine is an organic base and is neutralized by acids (such as HCl) in molecular proportions. It also combines in molecular proportions with aldehydes. The HCl value of a certain phenylhydrazine solution is determined by titration; another batch (same volume) of the same hydrazine solution is treated with a definite amount of aldehyde and its hydrochloric acid value is determined by residual titration. The sample to which the aldehyde has been added will, of course, require less acid for neutralization than did the original phenylhydrazine solution, since a portion of the hydrazine was used up in combining with the aldehyde. The reaction runs

$$\underset{\text{Benzaldehyde}}{C_6H_5CHO} + \underset{\text{Phenylhydrazine}}{H_2N - NHC_6H_5} = \underset{\text{Aldehyde compound}}{C_6H_5CH = NNHC_6H_5} + \underset{\text{Water}}{H_2O}$$

The neutralization of the hydrazine can be expressed as follows:



$$H_2N—NHC_6H_5 + HCl = \begin{matrix} NHC_6H_5 \\ | \\ NH_3Cl \end{matrix}$$

Hence one molecule hydrochloric acid indirectly represents one molecule benzaldehyde.

Hence 36.47 Gm. absolute HCl = 106.05 Gm. absolute benzaldehyde,

$$\left.\begin{matrix}\text{0.01832 Gm. absolute HCl} \\ \text{(amount in 1 mil } n/2 \text{ HCl)}\end{matrix}\right\} = \frac{1832}{3{,}647{,}000} \times 106.05 = 0.053$$

Gm. absolute benzaldehyde.

In this way is deduced the factor 0.053 used in the assay given above.

Like benzaldehyde assay are the other three, viz.:

Oil of Bitter Almond is assayed by exactly the same method as is benzaldehyde.

Outline of Assay of Citral in Oil of Lemon.—Mix 15 mils of the oil with 10 mils of a 10 per cent. alcoholic phenylhydrazine solution and let the mixture stand for thirty minutes. Add some methyl orange T.S. and then neutralize by titration with *n*/2 HCl, V.S. If the neutralization is difficult, a special manipulation is suggested by the pharmacopœia. At the same time, run a blank test (omitting the oil) and note amount of *n*/2 HCl, V.S. needed to neutralize the phenylhydrazine solution. The difference between the number of mils of *n*/10 HCl, V.S. consumed by the straight phenylhydrazine solution and the phenylhydrazine solution treated with the oil, multiplied by 0.076 gives the weight of citral in 15 mils of the oil. For details see U.S.P., p. 294.

"CASSIA FLASK" ASSAYS OF VOLATILE OILS

At this place, mention should be made of the assays of oils for phenols or for aldehydes based upon the formation of a water-soluble compound of these substances and the subsequent liberation of the free phenol or aldehyde and the direct reading of its volume in a "cassia flask." Seven official oils are thus assayed—caraway (p. 751); clove (p. 749); cassia (p. 745); eucalyptus (p. 746); pimenta (p. 752); spearmint (p. 748) and thyme (p. 743). On the pages just designated the pharmacopœia assay for each oil is given in abstract.

SAPONIFICATION NUMBER OF OILS AND FATS

As already explained on p. 665, fixed oils and fats are esters of glycerin with fatty acids, and the process of soap-making is the cooking of such oils with soda or potassa, whereby the sodium or potassium salts of the fatty acids are obtained. This fact is utilized in the assay of oils and fats, a given weight of the fatty substance being boiled with a known excess of alcoholic potassium hydroxide T.S. (p. 886), and titrated with half-normal hydrochloric acid. In this way we can find out the exact amount of alkali taken up by the oil, and thus the "saponification number" can be deduced.

The pharmacopœial process may be outlined as follows:

Outline of the Estimation of the Saponification Value.—Accurately weigh 1.5 to 2.0 grammes of the fat or oil, mix with 25 mils of alcoholic KOH, V.S. and heat for thirty minutes on a water-bath in a flask provided with an upright condensing tube. Then titrate with $n/2$ HCl, V.S., using phenolphthalein T.S. as indicator. At the same time titrate 25 mils of alcoholic KOH, V.S. with $n/2$ HCl, V.S.

The difference between the number of mils of $n/2$ HCl, V.S. used by the straight alcoholic KOH, V.S. and by the same solution after treatment of the fat, multiplied by 28.055 and divided by the weight of the fat, gives the saponification value. For details see U.S.P., p. 590.

The saponification number means the number of milligrammes absolute potassium hydroxide which combines with 1 gramme of oil. Thus, taking an example of calculating by process given above, suppose 2 grammes of olive oil combines with 13.9 mils half-normal potassium hydroxide V.S. That is, suppose it takes 25 mils half-normal hydrochloric acid V.S. to neutralize 25 mils alcoholic potassium hydroxide *before* saponification, and 11.1 mils half-normal hydrochloric acid V.S. to neutralize the 25 mils alcoholic potassium hydroxide *after* saponification. The calculations in this case would be $25 - 11.1 = 13.9$,

$$\frac{13.9 \times 28.055}{2} = \frac{389.9645}{2} = 194.9$$

and the saponification number is 194.9.

Now let us see the amount of potassa combining with the oil:

1 mil $n/2$ KOH = 0.028055 Gm. absolute KOH (p. 886).
13.9 mils $n/2$ KOH = 13.9 × 0.028055 = 0.3899645 Gm. absolute KOH.

Hence we see that 2 Gm. oil combines with 390 milligrammes KOH
and 1 Gm. oil combines with 195 milligrammes KOH

SAPONIFICATION NUMBER OF OFFICIAL OILS AND FATS

The following oils and fats are thus assayed:

	Sap. No.		Sap. No.
Olive oil	190–195	*Oil of theobroma*	188–195
Expressed oil of almond	191–200	*Oil of sesame*	188–193
Cottonseed oil	190–198	*Cod-liver oil*	180–190
Linseed oil	187–195	*Lard*	193–203
Castor oil	179–185	*Suet*	193–200
Croton oil	200–215		

The manipulation employed in estimating the saponification number of storax differs from the routine method; hence it is printed below:

Storax.—Accurately weigh about 1 Gm. purified storax, mix with 50 mils of purified petroleum benzin, add 25 mils alcoholic KOH, V.S. and macerate twenty-four hours, with frequent shaking. Then titrate with $n/2$ HCl, V.S. Indicator, phenolphthalein. Saponification number, 170 to 230. For details see p. 417.

The assay of yellow wax differs from the saponification number determined in the fact that both free and ester value is determined in the same sample. The official directions are as follows:

Yellow Wax.—Accurately weigh about 3 Gm. wax, warm with 25 mils neutral dehydrated alcohol until melted and titrate, while warm with alcoholic KOH, V.S., using phenolphthalein as indicator. Acid value, 18 to 24. Then add another 25 mils alcoholic KOH, V.S. and some alcohol, boil for two hours in flask connected with reflux condenser and titrate excess of alkali with $n/2$ HCl, V.S. Ester value, 72 to 77. For details see U.S.P., p. 105.

The *ester assays* of volatile oils are modifications of the saponification number determination. Four volatile oils are thus assayed in the present pharmacopœia.

Methyl Salicylate.—Accurately weigh about 2 mils of the oil mix with 50 mils alcoholic KOH, V.S. heat for two hours on a water-bath, in a flask connected with a reflux condenser, then titrate excess of alkali with $n/2$ HCl, V.S. Indicator, phenolphthalein T.S. Strength, at least, 98 per cent. $CH_3C_7H_5O_3$.

Each mil $n/2$ alcoholic KOH, V.S. =0.07603 Gm. $CH_3C_7H_5O_3$. Each Gm. U.S.P oil = at least 12.9 mils $n/2$ alcoholic KOH, V.S. For details see U.S.P., p. 273.

The test for esters (as impurity) in oil of lavender (see U.S.P., p. 294 is a type of ester assay.

Oil of Peppermint (ester assay).—Accurately weigh 10 mils of the oil and boil with 25 mils alcoholic KOH, V.S. for one hour in a flask connected with a reflux condenser. After cooling, titrate the excess of alkali with $n/2$ H_2SO_4, V.S., using phenolphthalein as indicator. The number of mils of alcoholic KOH, V.S. consumed by the oil multiplied by 9.909 and divided by the weight of the oil, gives the percentage of menthyl acetate. For details see U.S.P., p. 296.

Oil of Peppermint (menthol assay).—Acetylize 10 mils of the oil by heating in an acetylization flask with acetic anhydride and anhydrous sodium acetate for one hour. Cool, and then wash, dry and accurately weigh about 5 mils of acetylized oil. Then boil the acetylized oil for one hour with 50 mils $n/2$ alcoholic KOH, V.S. in a flask connected with a reflux condenser. After cooling, titrate excess of alkali with $n/2$ H_2SO_4, V.S., using phenolphthalein T.S., as indicator. For the menthol calculation and other details see U.S.P., p. 296.

Oil of Rosemary (ester and borneol assays) exactly like the ester and menthol assays of oil of peppermint except that the factor is different. For details see U.S.P., p. 30

It will be noticed that there are two parts to the assay of oil of peppermint and oil of rosemary: The first part resembling a saponification number determination, while the second part—a phenol assay—depends upon the acetylization of that substance.

As to the saponification tests, it will be seen that the factor 9.909 for the menthyl acetate of oil of peppermint; 9.808 for the bornyl acetate of oil of rosemary) represents the molecular weight of the characteristic ester divided by 200, or 100 times the amount of ester that combines with 1 mil half-normal potassium hydroxide V.S.

This can best be explained by a hypothetic assay.

Suppose we find 9 grammes of oil of peppermint combine with 7.5 mils half-normal alcoholic KOH; that is, while the 25 mils half-normal alcoholic KOH took 25 mils half-normal H_2CO_4 *before* saponification after saponification the alkali left took only 17.5 mils half-normal H_2SO_4. In such cases we find—

that (*a*) 9 Gm. oil = 7.5 mils $n/2$ alcoholic KOH.
that (*b*) 1 mil $n/2$ alcoholic KOH = 0.09909 Gm. menthyl acetate.
that (*c*) 7.5 mils $n/2$ alcoholic KOH = 7.5×0.09909.
= 0.743175 Gm. menthyl acetate.
Therefore that (*d*) 9 Gm. oil = 0.743175 Gm. menthyl acetate.
and that (*e*) 9 Gm. oil $= \frac{100}{9} \times 0.743175 = 8.2$ per cent. menthyl acetate.

Careful examination of the above figures shows that the real calculation "c" and "e" means the multiplication of the number of mils of alcoholic potassa used by 0.09909 and by 100 (or by 9.909), and finally dividing by weight of oil. In passing, it may be stated that the use of the acetylization factors 7.808 for the menthol in oil of peppermint and 7.707 for the borneol in oil of rosemary) can be explained in the same way.

The *acetylization tests* given above for oil of peppermint and for oil of rosemary, as well as that for the santalol in oil of santal, given below, are based on the fact that the characteristic alcohols of these three oils form well-defined acetyl compounds when boiled with acetic acid anhydride and sodium acetate, in the appropriate "acetylization flask" (Fig. 249); that this oil, separated from the aqueous liquid, washed with water, and dried, can be saponified like any other ester, and from the amount of alcoholic potassa required for saponification the amount of alcohol can be estimated.

The oils thus assayed are:

Oil of Peppermint.—See U.S.P., p. 296.

Oil of Rosemary.—See U.S.P., p. 300.

Oil of Santal.—Like assay for menthol in oil of peppermint, except that the factor is 11.11.

THE ACID NUMBER OF RESINS

As mentioned on p. 773, true resins contain resin acids. These resin acids, like other acids, combine with alkali in definite proportions. Hence their amount can be estimated by titration with volumetric alkali solution. The pharmacopœial directions for acid number estimations may be summarized as follows:

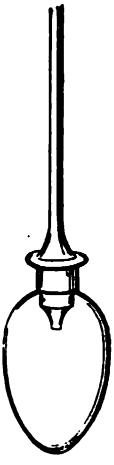


Fig. 249.—Acetylization flask.

Acid Number for Resins.—This represents the number of milligrammes of potassium hydroxide required to neutralize 1 gramme of resin. Accurately weigh about 2 Gm. resin, dissolve it in alcohol and titrate with $n/2$ KOH, V.S. The pharmacopœia also suggests adding an excess of $n/2$ KOH, V.S. and then titrating back with half-normal acid. Each mil of half-normal alkali used, multiplied by 0.028055 and divided by the weight of the resin equals the acid number. For details see U.S.P., p. 591.

The official substances so tested are:

	Acid Number
Rosin	Not less than 150
Storax	56 to 85
Balsam of Tolu	154 to 220
Balsam of Peru (Cinnamein value)	235 to 238

The manipulation of the last three cases is quite complex. For details see U.S.P.

IODINE ABSORPTION NUMBER

As already explained on p. 569, fixed oils, like all other unsaturated bodies, when treated with halogens, notably iodine, loosen whatever double bonds they possess, attaching an atom of the halogen to each bond thus freed; hence each double bond in such oil takes up two atoms of iodine. As the percentage of unsaturated ester differs in each fixed oil, the different fixed oils absorb different amounts of iodine; hence the iodine absorption number is a valuable aid to identification and differentiation of oils.

The pharmacopœia gives a monograph on the subject that may be summarized as follows:

Accurately weigh about 0.8 Gm. solid fat or 0.3 Gm. oil (exceptions linseed, codliver oil and theobroma oils) dissolve it in chloroform and add to the solution iodo-bromide test solution U.S.P. Macerate one-half hour (longer with castor and linseed oils) being sure that at the end of the maceration, the mixture is colored brown by free iodine. Then add potassium iodide and distilled water and titrate the excess of iodine with *n*/10 sodium thiosulphate V.S., using starch paste as indicator. Run a blank test of the iodo-bromide T.S. with the thiosulphate V.S. and the difference between the mils of *n*/10 $Na_2S_2O_3$, V. S. used by the straight iodo-bromide solution and used by the number of mils used by the same solution after treatment with fat, multiplied by 1.269 and divided by the weight of the fat, gives the iodine value of the fat. The iodo-bromide solution is made by dissolving iodine in glacial acetic acid and then adding bromine to the solution. For details see U.S.P., p. 590.

Explaining the arithmetic of this process, let us suppose that 0.3 gramme of a certain fat plus 25 mils iodo-bromide T.S. take 60 mils tenth-normal thiosulphate V.S. to decolorize, while in the blank experiment 25 mils iodo-bromide T.S. take 90 mils tenth-normal thiosulphate V.S. for decolorization. This would mean that 0.3 gramme fat absorbed $90-60$, or 30 mils tenth-normal thiosulphate V.S.

1 mil *n*/10 thiosulphate V.S. = 0.012692 Gm. iodine (p. 893).
30 mils *n*/10 thiosulphate V.S. = 30×0.012692 Gm. iodine.
= 0.38076 Gm. iodine.
Hence 0.3 Gm. fat absorbed 0.38076 Gm. iodine.
Hence 100 Gm. fat would absorb $\frac{1000}{3} \times 0.38076$ Gm. iodine.
or 126.9 Gm. iodine.

The factor as given in the pharmacopœia is: subtract from amount thiosulphate V.S. consumed in blank test (in our case, 90 mils) the amount consumed in actual test (in our case, 60 mils) and the difference (30, in our case) multiplied by 1.269 and divided by weight of fat taken (in our case 0.3 Gm.) gives the iodine value

$$\frac{30 \times 1.269}{0.3} = 126.9$$

which shows that the so-called "iodine number" means *the number of grammes of iodine absorbed by* 100 *grammes of fat.*

The following official oils are tested exactly as in the process given above:

	Iodine value		Iodine value
Castor Oil	83– 88	Sesame Oil	103–112
Codliver Oil	140–180	Oil of Theobroma	33– 38
Cottonseed Oil	105–114	Lard	46– 70
Croton Oil	104–110	Suet	33– 48
Expressed Oil of Almond	93–100	Wool Fat	18– 28
Linseed Oil	at least 170	Soap (Acids from)	84– 90
Olive Oil	79– 90		

SPECIAL ORGANIC VOLUMETRIC ASSAYS

I. PHENOL ASSAY WITH KOPPESCHAAR'S SOLUTION

As the theory of this assay is given on p. 688, it is merely necessary to insert pharmacopœial directions and to calculate results:

TENTH-NORMAL BROMINE VOLUMETRIC SOLUTION

[Koppeschaar's Solution]

Br = 79.92 7.992 Gm. in 1000 mils

Condensed Recipe.

Dissolve 3 Gm. potassium bromate and 50 Gm. potassium bromide in enough water to make 1000 mils. Standardize 20 mils of this by treatment with purified hydrochloric acid and potassium iodide and then titrate the liberated iodine with $n/10$ sodium thiosulphate V.S. Then dilute the bromine solution so that each mil corresponds to 1 mil $n/10$ $Na_2S_2O_3$,V.S. The pharmacopœia also discusses the arithmetic of the dilution. For details see U.S.P., p. 558.

The pharmacopœia gives the equivalent factor for four chemicals assayed with tenth-normal bromine V.S. In the case of two of these—sodium phenolsulphonate (anhydrous and crystalline)—the factor (grammes of chemical represented by 1 mil of tenth-normal bromine V.S.) is *the molecular weight of the substance divided by* 40,000 while with the other two—phenol and resorcinol—the factor is *the molecular weight divided by* 60,000.

The following official chemicals are assayed with this reagent.

Phenol.—Treat a known quantity of an aqueous solution of phenol (containing between 0.038 and 0.041 Gm. C_6H_5OH) with 30 mils of $n/10$ bromine V.S., add hydrochloric acid and potassium iodide solution, then add a little chloroform and titrate with $n/10$ sodium thiosulphate V.S. From amount of $n/10$ $Na_2S_2O_3$, V.S. used, calculate amount of $n/10$ Br, V.S. used by the phenol.

Each mil $n/10$ Br, V.S. = 0.001568 Gm. C_6H_5OH. Each Gm. U.S.P. phenol = 618.6 mils $n/10$ Br, V.S. For details see U.S.P., p. 317.

It will be seen that a certain amount of bromine is absorbed by the phenol; that the excess liberates iodine from the added potassium iodide, and that the iodine thus freed is titrated with tenth-normal thiosulphate solution.

We have already learned (p. 892) that 1 mil tenth-normal thiosulphate V.S. equals 1 mil tenth-normal iodine V.S., and as the bromine liberates iodine atom for atom, 1 mil tenth-normal thiosulphate solution must equal 1 mil tenth-normal bromine solution.

We find above that 1 mil $n/10$ bromine V.S. = 0.001568 Gm. phenol. This is because the reaction between bromine and phenol runs as follows:

$$\begin{array}{ccccccc} C_6H_5OH & + & 6Br & = & C_6H_2Br_3OH & + & 3HBr. \\ 94.05 & & 6\times79.92 & & & & \\ & & \text{or } 479.52 & & & & \end{array}$$

We therefore see—

$$\begin{array}{rcl} 479.52 \text{ Gm. Br.} & & = 94.05 \text{ Gm. } C_6H_5OH. \\ \text{Hence } 79.92 \text{ Gm. Br} & = \dfrac{94.05}{6} & = 15.68 \text{ Gm. } C_6H_5OH. \\ \left.\begin{array}{r}\text{and } 7.992 \text{ Gm. Br.} \\ \text{or } 1000 \text{ mils } n/10 \text{ Br. V.S.}\end{array}\right\} & & = 1.568 \text{ Gm. } C_6H_5OH. \\ \text{Hence } 1 \text{ mil } n/10 \text{ Br, V.S.} & = 0.001568 \text{ Gm. } C_6H_5OH. & \end{array}$$

In the pharmacopœial assay of phenol we take a solution equivalent to about 0.04 Gm. phenol, mix it with 30 mils tenth-normal bromine V.S., then with acid and potassium iodide, and finally titrate freed iodine with tenth-normal thio V.S. Suppose it takes 6 mils thiosulphate solution to decolorize, that would mean that there had been in the solution before adding the potassium iodide 6 mils tenth-normal bromine V.S., and that the phenol had combined with 30 − 6 or 24 mils tenth-normal bromine V.S.

Since 1 mil $n/10$ Br, V.S. = 0.001568 Gm. phenol.

24 mils $n/10$ Br, V.S. = 24 × 0.001568 Gm. phenol.

Hence 0.04 Gm. of the sample of phenol contained 0.037632 Gm. absolute phenol or $\frac{37,632}{40,000}$ of 100 per cent. or 94 per cent. absolute phenol.

Liquefied phenol is assayed like phenol. Each gramme corresponds to 554.8 mils $n/10$ Br, V.S.

Resorcinol.—Accurately weigh 1.5 Gm. resorcinol and dissolve in enough distilled water to make 1 liter. Mix 25 mils of this solution with 50 mils of $n/10$ Br, V.S., add water, hydrochloric acid and potassium iodide solution and then titrate the liberated iodine with $n/10$ $Na_2S_2O_3$, V.S., using starch paste as indicator. From the amount of $n/10$ $Na_2S_2O_3$, V.S. used, calculate the amount of $n/10$ Br, V.S. used by the resorcinol.

Each mil $n/10$ Br, V.S. = 0.001834 Gm. $C_6H_4(OH)_2$. Each Gm. U.S.P. resorcinol = 542.5 mils $n/10$ Br, V.S. For details see U.S.P., p. 360.

Sodium Phenolsulphonate.—Accurately weigh about 0.25 Gm. sodium phenolsulphonate, dissolve it in distilled water, add 50 mils of $n/10$ Br, V.S., hydrochloric acid and, later potassium iodide solution. Then titrate with $n/10$ $Na_2S_2O_3$, V.S., using starch paste as indicator. From the amount of $n/10$ $Na_2S_2O_3$, V.S. used calculate the amount of $n/10$ Br, V.S. consumed by the phenolsulphonate.

Each mil $n/10$ Br, V.S. = 0.04903 Gm. $NaC_6H_5O_4S$. Each Gm. U.S.P. phenolsulphonate = 170 to 179.1 mils $n/10$ Br, V.S. For details see U.S.P., p. 395.

II. SUGAR ASSAY WITH FEHLING'S SOLUTION

This assay has been discussed on p. 625, and as neither of the official sugars is directed to be assayed, we can leave the subject after presenting an outline of the pharmacopœial directions and a few additional remarks.

ALKALINE CUPRIC TARTRATE VOLUMETRIC SOLUTION

[FEHLING'S SOLUTION]

Condensed Recipe.

Two solutions are prepared.

Solution A consists of 34.66 Gm. uneffloresced copper sulphate U.S.P. dissolved in enough distilled water to make 500 mils.

Solution B is made by dissolving 173 Gm. crystalline potassium and sodium tartrate U.S.P. and 50 Gm. sodium hydroxide U.S.P. in enough distilled water to make 500 mils. Mix equal volumes of the two solutions at the time of titration. The pharmacopœia gives directions for keeping these solutions and also the equivalent factors for carbohydrates. Each mil of the mixed solution represents 0.00500 Gm. anhydrous glucose; 0.00475 Gm. cane sugar after inversion; and 0.00678 Gm. anhydrous milk sugar. For details see U.S.P., p. 557.

It will be seen from the above that 10 mils of mixed solution equals 5 centigrammes (0.05 Gm.) of glucose. In carrying out the assay, 10 mils mixed solution is put into an evaporating dish, is diluted with water (say 50 mils), and is brought to the boiling-point.

The diluted sugar solution (usually diabetic urine, as far as the pharmacist is concerned) is put into a burette and is poured into the boiling solution, little by little, until all the copper is precipitated. Details are beyond the scope of this work; hence the reader is referred to some standard book on urinary analysis such as Hawk's Physiological Chemistry.

The process outlined above involves a peculiar form of calculation; for we see that in this case, contrary to the usual assay, the volumetric solution is measured and the liquid whose strength is to be determined is dropped from the burette. This makes our report read something like this: 10 mils Fehling's solution was completely precipitated by 15 mils of urine. In such case the calculation runs as follows:

10 mils Fehling's solution = 15 mils urine.
10 mils Fehling's solution = 0.05 Gm. glucose.

Hence 15 mils urine contained 0.05 Gm. glucose.
Hence 100 mils urine contained $\frac{100}{15}\times 0.05$ or 0.333 Gm. glucose.

and we ordinarily say that such urine contains 0.333 per cent. (⅓ of 1 per cent.) glucose, although bear in mind that in exact chemical operations percentage should mean grammes to 100 grammes, and not grammes to 100 mils.

Before leaving Fehling's solution mention should be made of its modification—Pavy's solution. This is made by adding 12 mils mixed Fehling's solution to 30 mils stronger ammonia water, 10 mils 10 per cent. soda, and water to make 100 mils. This mixture is boiled in a flask protected from air by having a layer of melted paraffin floating on its surface. When all the copper is taken up by the urine dropped from the burette, the blue solution becomes colorless. As no precipitate of cuprous oxide forms, the end of the reaction is much easier to note than it is in the Fehling's process.

The above 100 mils mixture represents 0.05 Gm. glucose; in short, has exactly the same value as 10 mils Fehling's solution.

CHAPTER LVI

GRAVIMETRIC AND GASOMETRIC ASSAYS

Gravimetric analysis, as explained on p. 859, is the estimation of the quantity of a certain ingredient of a given substance by the separation of this ingredient, free, in combination, or possibly in reduced form, weighing the solid so separated, and from the weight obtained deducing the amount in the original compound.

Ordinarily, the process consists of precipitating the ingredient as an insoluble compound, but in the final grouping this class of analysis includes such assays as the extracting and weighing of alkaloids (see Cinchona Assay, p. 907, the burning of organic salts as carbonates, which are then weighed, and the separation of a button of metal from the ore in the so-called fire assays.

The pharmacopœial gravimetric assays may be grouped into (*a*) precipitation assays; (*b*) incineration of metallic compounds and weighing the resulting oxide; (*c*) isolation of mercury from its ointments.

Precipitation assays are conducted by taking an aqueous solution of a soluble salt, adding thereto the appropriate precipitant (p. 142), collecting the insoluble form of the desired ingredient thus precipitated, and weighing same after carefully washing free from soluble impurity and after heating until all moisture and volatile impurities are driven off. The process can best be explained by a few typical examples.

We want to estimate the amount of sulphuric acid in a certain batch of dried sodium sulphate. We take 0.2 Gm. of the sulphate, dissolve in water, and add barium chloride T.S., when the following reaction occurs:

$$(a)\ \underset{142.07}{Na_2SO_4} + \underset{208.29}{BaCl_2} = \underset{2\times 58.46}{2NaCl} + \underset{233.44}{BaSO_4}.$$

The insoluble barium sulphate is collected on a filter, washed, dried, and weighed, when we find in the case under consideration that 0.2 Gm. Na_2SO_4 gave 0.325 Gm. $BaSO_4$.

From the equation above we find:

0.233 Gm. $BaSO_4 = 0.142$ Gm. absolute Na_2SO_4.

Then 0.325 Gm. $BaSO_4 = \frac{325}{233} \times 0.142 = 0.197$ Gm. absolute Na_2SO_4.

Hence we see that the 0.2 Gm. sodium sulphate contained 0.197 Gm. absolute Na_2SO_4.

If it is desired to estimate only the acidulous portion (SO_4) of the sodium sulphate, the calculation runs like this:

$$\begin{array}{ccccccc} Na_2SO_4 & + & BaCl_2 & = & 2NaCl & + & BaSO_4. \\ 46+96.07 & & 208.29 & & 2\times58.46 & & 233.44 \\ 142.07 & & & & & & \end{array}$$

0.233 Gm. $BaSO_4 = 0.096$ Gm. SO_4.

Then 0.325 Gm. $BaSO = \frac{325}{233} \times 0.096 = 0.133$ Gm. SO_4.

We therefore see that

0.2 Gm. Na_2SO_4 contained 0.133 Gm. SO_4,

or $\frac{133}{200} \times 100 = 67.5$ per cent. SO_4.

Another case, showing that the process is applicable to the estimation of the basic constituent of a salt as well as the acidulous portion, might be given. 0.2 Gm. silver nitrate is precipitated by hydrochloric acid as silver chloride, as shown in the following equation:

$$\begin{array}{ccccccc} AgNO_3 & + & HCl & = & AgCl & + & HNO_3. \\ 169.89 & & 36.47 & & 143.34 & & 63.02 \end{array}$$

We find in the assay that 0.2 Gm. silver nitrate gives 0.165 Gm. dried silver chloride.

From the equation above we find that—

0.143 Gm. $AgCl = 0.169$ Gm. absolute $AgNO_3$.

Then 0.165 Gm. $AgCl = \frac{165}{143} \times 0.169 = 0.195$ Gm. absolute $AgNO_3$.

Hence 0.200 Gm. of the silver nitrate contained 0.195 Gm. absolute $AgNO_3$ or $\frac{195}{200} \times 100$ per cent., or 97.5 per cent. absolute $AgNO_3$.

Expressed as quantity of metallic silver, the calculation runs like this:

$$\begin{array}{ccccccc} \overbrace{Ag \quad NO_3} & + & HCl & = & AgCl & + & HNO_3. \\ \underbrace{107.88 \quad 62.01}_{169.89} & & 36.47 & & 143.34 & & 63.02 \end{array}$$

0.143 Gm. $AgCl = 0.108$ Gm. metallic silver.

Then 0.165 Gm. $AgCl = \frac{165}{143} \times 108 = 0.124$ Gm. metallic silver.

Hence 0.200 Gm. of the silver nitrate contains 0.124 Gm. metallic silver, or $\frac{124}{200} \times 100$ per cent. $= 62$ per cent. metallic silver.

The above sketchy outline gives but a glimpse of the important and difficult branch, gravimetric analysis, and for details of the work the reader is referred to such standard works on the subject as Treadwell and Hall or Fresenius. Before dismissing the subject, the statement should be made that in gravimetric calculations exact molecular weights should be used; that weights and calculations should be carried to the fourth decimal place, and that because of the extreme skill required to obtain accurate results, the process is not largely used in pharmacopœial assays.

The precipitation assays of the present pharmacopœia can be grouped as follows:

1. Precipitation as barium sulphate and weighing as such.
2. Precipitation as magnesium phosphate and weighing as magnesium pyrophosphate.
3. Precipitation as calcium oxalate and weighing as calcium oxide.
4. Precipitation as aluminum hydroxide and weighing as aluminum oxide.
5. Precipitation as zinc sulphide and weighing as zinc oxide.
6. Precipitation as metallic gold and weighing as such.
7. Precipitation as mercuric sulphide and weighing as such.
8. Precipitation as uranium hydroxide and weighing as uranium oxide.

THE BARIUM SULPHATE ASSAYS

This type of assay has been explained on p. 860, so we can proceed to the study of pharmacopœial directions.

Sodium Sulphate.—Accurately weigh about 1 Gm. sodium sulphate, dissolve in distilled water, acidulate with hydrochloric acid, heat to boiling and then precipitate by adding an excess of hot barium chloride T.S., heat mixture thirty minutes on a water-bath, then collect the $BaSO_4$ on a filter, wash until free from chlorides, then ignite and weigh.

Each Gm. U.S.P. sulphate = 0.717 to 0.789 Gm. $BaSO_4$. For details see U.S.P., p. 399.

Sublimed Sulphur.—Accurately weigh about 1 Gm. well-dried sulphur, mix with 50 mils of 10 per cent. potassium hydroxide solution and boil until a clear golden-yellow liquid results. Dilute this with distilled water and then oxidize one-tenth of it with solution of hydrogen dioxide. Acidulate the resulting solution of sodium sulphate with hydrochloric acid, dilute it with water, heat to boiling, add hot barium chloride T.S. and then heat the mixture on a water-bath for thirty minutes. Collect the precipitate of barium sulphate, wash, dry, ignite and weigh it. Also run a blank test and if any barium sulphate precipitate occurs, weigh it and deduct from the weight of barium sulphate obtained in the real assay.

Each Gm. U.S.P. sulphur = 7.243 Gm. $BaSO_4$. For details see U.S.P., p. 421.

In this assay, the sulphur is made soluble by boiling with alkali (p. 381) the resulting potassium sulphide is oxidized with hydrogen dioxide to the sulphate which is then precipitated with barium chloride.

THE MAGNESIUM PHOSPHATE ASSAYS

These are based upon the fact that when a magnesium salt is treated with sodium phosphate in alkaline (ammoniacal) solution ammonio-magnesium phosphate precipitates (p. 871). This magnesium phosphate upon heating is converted into the pyrophosphate, which is weighed.

Magnesium Sulphate.—Accurately weigh about 1 Gm. magnesium sulphate, dissolve it in water, add to the solution, sodium phosphate T.S. and then ammonia water and let mixture stand for four hours. Collect the precipitate on a filter, wash it with a diluted ammonia water until free from sulphate, then dry and ignite.

Each Gm. U.S.P. sulphate = 0.4944 Gm. $Mg_2P_2O_7$. For details see U.S.P., p. 265.

Solution of Magnesium Citrate.—Evaporate 10 mils of solution to dryness, ignite and when most of the carbon has burned off treat the residue with diluted hydrochloric acid, filter and then wash the residue with hot water. The filtrate is then treated as in the assay of magnesium sulphate. For details see U.S.P., p. 249.

THE CALCIUM OXALATE ASSAY

In these assays, the calcium is precipitated from its solution by addition of a solution of ammonium oxalate. The calcium oxalate (p. 871) thus produced is strongly heated, when calcium oxide, CaO, remains. But one such assay is given in the pharmacopœia.

Calcium Glycerophosphate.—Accurately weigh about 0.4 Gm. well-dried glycerophosphate, dissolve it in a diluted solution of acetic acid. Heat the solution to boiling and treat with ammonium oxalate T.S. Collect the precipitate, wash, dry, ignite, and weigh the resulting calcium oxalate.

Another sample is ignited direct and the resulting calcium pyrophosphate is weighed. For details see U.S.P., p. 92.

THE ALUMINUM HYDROXIDE ASSAYS

In these, a solution of the aluminum salt is treated with ammonium hydroxide, usually after the addition of a solution of ammonium chloride. The precipitate of aluminum hydroxide (p. 872) thus produced is heated, when the oxide, Al_2O_3, is produced.

Alum.—Accurately weigh about 1 Gm. alum, dissolve it along with 1 Gm. ammonium chloride in distilled water, boil and add a slight excess of ammonia water. Collect the precipitate, wash with hot distilled water, dry, ignite and weigh as Al_2O_3.

Each Gm. Al_2O_3 = 8.874 Gm. ammonium alum or 9.286 Gm. potassium alum. For details see U.S.P., p. 40.

Exsiccated Alum.—Like alum, except that about 0.25 gramme of salt is taken. Each gramme of oxide corresponds to 4.643 Gm. ammonia alum or 5.055 Gm. potassa alum.

THE ZINC SULPHIDE ASSAYS

When zinc salts are treated with ammonium sulphide in alkaline solution, a white precipitate of zinc sulphide (p. 871) results. When this is heated, zinc oxide is produced.

Zinc Acetate.—Accurately weigh about 1 Gm. zinc acetate, dissolve in distilled water, add ammonia water to faint alkalinity, warm to 80°C. and then add ammonium sulphide T.S. and warm on a water-bath. Collect the precipitate, wash with distilled water containing a trace of ammonium sulphide, then dissolve it hot 20 per cent. nitric acid, evaporate, ignite and weigh as zinc oxide.

Each Gm. U.S.P. acetate = 0.369 to 0.387 Gm. ZnO.

Other zinc salts for which similar assays are directed in the present pharmacopœia are:

	Amount taken for weighing	Each gramme oxide obtained represents, of salt
Zinc Phenolsulphonate	1 Gm.	6.53 to 6.84 Gm.
Zinc Sulphate	1 Gm.	1.70 to 1.79 Gm.
Zinc Valerate	1 Gm.	3.76 Gm.

For details see U.S.P.

Zinc.—Accurately weigh about 1 Gm. zinc, dissolve it in hydrochloric acid and add enough distilled water to make 100 mils. Take 10 mils of this solution, dilute with distilled water, add ammonia water to faint alkalinity and treat as in the assay for zinc acetate.

Each Gm. zinc = 1.232 Gm. ZnO. For details see U.S.P., p. 496.

THE OFFICIAL GOLD ASSAY

Gold and Sodium Chloride.—Accurately weigh about 0.5 Gm. of the well-dried double chloride, dissolve in 10 mils of distilled water, add 10 mils of potassium hydroxide T.S., heat on a water-bath and reduce to metallic gold by addition of solution of hydrogen dioxide. Wash the gold with acidulated water, dry, ignite and weigh.

Each Gm. U.S.P. salt = 0.30 Gm. Au. For details see U.S.P., p. 70.

THE OFFICIAL MERCURY ASSAYS

Corrosive Mercuric Chloride.—Accurately weigh about 0.5 Gm. well-dried chloride, dissolve in distilled water containing a little hydrochloric acid and then saturate the solution with hydrogen sulphide gas. Collect the precipitated mercuric sulphide on counterpoised filters, wash with water, then with alcohol, then with carbon tetrachloride, and again with alcohol. Dry at 110°C. and weigh.

Each Gm. U.S.P. bichloride = 0.8568 Gm. HgS. For details see U.S.P., p. 214.

Ammoniated Mercury.—Accurately weigh about 0.5 Gm. ammoniated mercury and dissolve it in hydrochloric acid and water by aid of gentle heat, then dilute with water and proceed as in the assay of corrosive mercuric chloride.

Each Gm. U.S.P. ammoniated mercury = 0.9047 to 0.9279 Gm. HgS. For details see U.S.P., p. 221.

Poison Tablets of Corrosive Mercuric Chloride.—Like that of the salt itself. For minor differences see U.S.P., p. 470.

THE OFFICIAL URANIUM ASSAY

Uranium Nitrate.—Accurately weigh about 0.4 Gm. uranyl nitrate, dissolve it in distilled water, heat to boiling, add ammonia water, collect the precipitate of uranium oxide, wash it with a 1 per cent. solution of ammonium nitrate, ignite at moderate heat and weigh as urano-uranic oxide.

Each Gm. U.S.P. nitrate = 0.548 Gm. U_3O_8. For details see U.S.P., p. 483.

THE OFFICIAL BISMUTH ASSAYS

Bismuth Betanaphthol.—Accurately weigh about 2 Gm. bismuth betanaphthol, incinerate, dissolve the residue in nitric acid, evaporate the solution to dryness, carefully ignite and then weigh the resulting bismuth oxide.

Each Gm. U.S.P. compound = 0.730 to 0.780 Gm. Bi_2O_3. For details see U.S.P., p. 79.

The following bismuth compounds are assayed in a similar manner.

Salt	Amount taken for weighing	Each gramme oxide represents, of salt
Bismuth and Ammonium Citrate...	1.0 Gm.	1.93 to 2.17 Gm.
Bismuth Subcarbonate...........	1.0 Gm.	1.11 Gm.
Bismuth Subgallate...............	1.0 Gm.	1.75 to 1.92 Gm.
Bismuth Subnitrate...............	1.0 Gm.	1.26 Gm.
Bismuth Subsalicylate	1.0 Gm.	1.51 to 1.61 Gm.
Magma of Bismuth...............	10.0 Gm.	16.13 to 17.85 Gm.

For details see U.S.P.

The following ignition assay is self explanatory.

Tincture of Iodine (for potassium iodide).—Evaporate 10 mils of the tincture on a water-bath, then volatilize the iodine by gentle heat and weigh the residue.

Each 1 mil of tincture = 0.045 to 0.055 Gm. K.I. For details see U.S.P., p. 458.

SPECIAL MERCURY ASSAYS

The assays for *mercurial ointment* and *diluted mercuric ointment* consist in dissolving out the fat with petroleum benzin and then weighing the residual mercury. (See p. 552.)

Before closing the subject of gravimetric assays attention must be called to the eight assays of this character in which the alkaloids are extracted from salts by the "shaking out" process and then weighed. A typical one is the following:

Iron and Quinine Citrate (assay for quinine).—Accurately weigh about 1 Gm. double citrate, dissolve in 20 mils of water, pour into a separator, add ammonia water and then shake out with three portions of chloroform. Evaporate the chloroformic extracts, redissolve residue in alcohol and then evaporate to dryness and weigh.

Each Gm. U.S.P. citrate = 0.115 Gm. quinine. For details, see U.S.P., p. 168.

The others, which have already been given on previous pages of this book are *caffeine citrate* (p. 680) *effervescent caffeine citrate* (p. 680), *caffeine* *sodio-benozate* (p. 679), *codeine phosphate* (p. 824), *quinine and urea-hydrochloride* (p. 812), *quinine tannate* (p. 814) and *theobromine sodio-salicylate* (p. 680). Lastly the collodion assay for pyroxylin (p. 213) might be considered as a gravimetric process.

VOLATILE AND NON-VOLATILE EXTRACTIVE DETERMINATIONS

In the case of spices, the determination of the volatile and non-volatile extractive matter is of value in deciding quality.

The present pharmacopœia (Part 2, Tests 12 and 13) has two monographs on the subject which may be summarized as follows:

Determination of Volatile Extracture.—Extract 2 gm. drug with anhydrous ether in a continuous extraction (Soxhlet) apparatus. Dry in a desiccator over sulphuric acid and weigh. This gives the total ether extract. Then heat the residue to constant weight at 110°C. The loss in weight represents the ether-soluble volatile extractive; while the weight after heating at 110°C. is non-volatile ether-soluble extractive. For details see U.S.P., pp. 591 and 592.

The spices for which these tests are produced are as follows:

Drug	Percentage of volatile extractive
Clove	Not less than 10.0 per cent.
Saigon Cinnamon	Not less than 2.0 per cent.
Ceylon	Not less than 0.5 per cent.
Coriander	Not less than 0.5 per cent.
Cubeb	Not less than 10.0 per cent.

GASOMETRIC ANALYSIS

This form of analysis is performed by liberating certain gases from appropriate substances by chemical action, measuring amount of gas obtained in a nitrometer (Fig. 239) or other measuring tube for gases; from the volume of the gas calculate its weight, and from its weight calculate the amount of chemical from which the gas was liberated. Only two official chemicals are assayed by this process—spirit of nitrous ether and amyl nitrite—and as the principle of assay was explained in the discussion of the preparation first mentioned (p. 596), it is unnecessary at this place to do more than insert a summary of the pharmacopœial description of the process.

The monograph describes the nitrometer, states how it should be filled with a saturated aqueous solution of sodium chloride, and points out the precautions necessary in running the reagents (potassium iodide and „H_2SO_4, V.S.)as well as the chemical solution that is to be tested.

It emphasizes the necessity of careful observation, not only of the volume of gas evolved, but also of the temperature and of the barometric pressure. It gives tables of correction for temperatures ranging from 15° to 35°C. and for barometric pressure ranging from 540 to 790 mm.; as well as examples of the calculations of such corrections.

It states that 1 liter of NO gas weighs 1.3406 Gm. at 0°C. and 760 mm. and 1.2281 Gm. at 25°C. and 760 mm. It also gives the equivalent factors for amyl nitrite both at 0°C. and at 25°C. For details see U.S.P., p. 600.

Colorimetric Assays.—In those cases where the quantity of substance is too small to determine either gravimetrically or volumetrically recourse is had to the fact that the intensity of a color reaction is proportional to the amount of the chemical present. Thus on p. 449 it was stated that Nessler's reagent was used to estimate minute amounts of ammonia present in water, space prevents extended description of this method of assay and the reader is referred to the articles by the author and his co-workers on the subject. (*Proc. Eighth Int. Cong. App. Ch.*, 26, 1912, 319; *Dr. Circ.*, 57, 1914, 131; *Jl. Frank Inst.* 180, 1915, 199; *Jl. A.Ph.A.*, 4, 1915, 1294; *Jl. Ind. Eng. Ch.*, 8, 1916, 309).

One such colorimetric test has been introduced with the present pharmacopœia:

> *Dried Suprarenals.*—Mix 0.01 Gm. dried suprarenals with 0.005 Gm. manganese dioxide and 10 mils of water, shake well, filter and compare the color of the filtrate with the color of mixtures of gold chloride T.S. and cobaltous chloride T.S. The pharmacopœia gives receipes for the gold-cobalt mixtures corresponding in color to 0.2, 0.4, 0.6 and 0.8 of 1 per cent. of epinephrin and states that the maceration of 0.01 Gm. dried suprarenals in 10 mils of distilled water, as outlined above, should show them to contain from 0.4 to 0.8 per cent. epinephrin. For details see U.S.P., p. 424.

Electrolytic Assays.—On p. 352 it was stated that when a current of electricity was passed through a solution of certain metallic salts, dissociation took place and the metallic ions migrate toward the negative pole where they lose their electric charge and deposit as the metal. If the proper conditions of temperature, time, strength of solution and of current are observed the metal deposits quantitatively and from its weight can be deduced the quality of the salt. The present pharmacopœia permits, as an optional method, the electrolytic assays of mercury and zinc salts. It gives (Part 2, Test 4) a detailed account of the proper manipulation, to which the reader is referred.

Polariscopic Assays.—We have already learned (p. 735) that the purity of many organic substances may be determined by estimation of their optical rotation. To this fact we must now add the statment that the rotation of a solution of an optically active substance—say, sugar or camphor—is directly proportional to the strength of the solution. Thus the polariscope is not only of service in detecting impurities, but it can also be used in assaying the strength of preparations containing optically active chemicals. Two such polariscopic assays are provided in the present pharmacopœia; one for *liniment of camphor;* the other for *spirit of camphor.* The student should refer to these assays as given in the pharmacopœia and should also read the general explanation of optical activity found on page 602 of that work.

Biological Assays.—On page 646 an outline of the principles of biological or physiological assays was given. Here it will be merely mentioned that in the present pharmacopœia such assays are compulsory as far as *cannabis, extract of cannabis, fluidextract of cannabis* and *tincture of cannabis* are concerned; while they are optional in the cases of *aconite, extract of aconite, fluidextract of aconite, tincture of aconite, digitalis, fluidextract of digitalis, tincture of digitalis, squill, fluidextract of squill, tincture of squill, strophanthus, tincture of strophanthus* and *dried suprarenals.* Details of manipulation to be followed in each of these assays are given in the pharmacopœia (page 604).

PART VI

THE DISPENSING OF PRESCRIPTIONS

CHAPTER LVII

THE PRESCRIPTION

Having covered the entire field of special pharmaceutic operations and preparations, we can proceed to dispensing pharmacy and to that climax of the pharmaceutic art, the dispensing of prescriptions. Very properly, the prescription is the last topic studied in a course on pharmacy, for the preparation of prescriptions calls into play all the knowledge that belongs to an educated pharmacist. Not only must the prescriptionist know pharmaceutic manipulations and be well acquainted with all pharmaceutic preparations, but he must, moreover, be thoroughly familiar with all possibilities of chemical reaction, with the constituents of crude drugs, and, of course, must be well up on posology—dosage. However, we will leave the important topic of prescription criticism for subsequent pages, and this chapter will be devoted to the generalities of dispensing and to a discussion of the general character of the prescription—its composition, translating, and dispensing.

The *prescription* is an order written by the physician calling for medicines to be compounded and dispensed by the pharmacist.

Technically, the ideal prescription is supposedly divided into several parts, which can best be explained after presentation of a typical prescription.

Ideal Prescription

(Date.) *August* 6, 1916
(Name of Patient.) For Mrs. Jones
(Superscription.) ℞.

(Inscription.)	Acidi salicylici	ʒiij.	(Basis.)
	Potassii acetatis	ʒiv.	(Adjuvant.)
	Glycerini	℥j.	(Corrective.)
	Aquæ q. s. ad.	℥iv.	(Vehicle.)

(Subscription.) Misce fiat solutio.
(Signa.) Sig.—One teaspoonful four times a day.
(Name of doctor.) Dr. Brown.

Taking up the parts of the prescription in regular order, the following information may be of service.

The *date* of a prescription is rarely written by the physician, but is of value in establishing its identity.

The *name of the patient* should always be written by the physician, and especially the information as to whether the patient is an infant, child, or adult. If the doctor omits this important datum, the pharmacist should supply it by writing the name and address on the prescription or on the card to which it is attached. There is usually little difficulty in persuading the patient to furnish name and address. To this may be added the emphatic statement that whenever the name does appear, it should be written on the label. Suppose, in handing the medicine to two customers, an exchange is effected, and Mrs. Smith gets the remedy intended for Mrs. Jones. If the label bears the inscription "For Mrs. Jones," that inscription might prove a warning and secure the return of the medicine to the pharmacy. Of course, such an error on the part of the pharmacist is scarcely excusable, but such errors sometimes occur, and lucky is the man who is saved from the possible disastrous results of a slip of that kind by the simple precaution just given.

The *superscription* is the sign which is an abbreviation of the Latin word "recipio," meaning "take thou." The flourish at the end of the R is presumably the sign of Jupiter, legend saying that Roman physicians used the sign, thus making the superscription an invocation "take thou in the name of Jupiter." This pleasant fable has never, however, been well authenticated. The French use the abbreviation "P," meaning "prenez," "take."

The *inscription* is the body of the prescription—the enumeration of the medicines desired and the quantity of each. As seen above, the inscription of the typical prescription may contain four groups of medicinal agents, although the modern physician is rapidly abandoning complex prescriptions, often prescribing a single ingredient.

Explaining these four groups:

The *basis* is the main ingredient—the medicine first indicated to the mind. Thus, in the above prescription (evidently for a rheumatic patient) the remedy first suggested was salicylic acid.

The *adjuvant* is the medicine intended to aid the basis in its medical action. In the above prescription the doctor evidently recalled that rheumatism is due to excess of uric acid, and decided to attempt to remove the uric acid by the use of the diuretic, potassium acetate. Hence this salt is the adjuvant—the assistant.

The *corrective* is some substance added to lessen irritating effect or improve flavor of the main ingredients. In the prescription given above glycerin is the corrective, but frequently flavored syrups or non-medicated elixirs are used as correctives.

The *vehicle*, or *diluent*, is the material added to dilute the preparation to a reasonable dose. Too much stress cannot be laid upon the danger of prescribing small doses, such as a few drops of a liquid. In the hands of the ignorant or careless fatal mistakes are apt to occur.

Most dangerous of all is the custom of some physicians in directing the patient to dilute a potent prescription at home. A fatal case of this kind occurring in Cleveland was the prescribing of tincture of aconite (U.S.P. 1890) for an infant, with the following remarkable directions: "Five drops in a glass of water, and then a teaspoonful every hour." The mother followed the directions implicitly, giving the babe five drops of the tincture in water, followed by a teaspoonful of the potent tincture!

The *subscription* includes the directions as to compounding intended for the guidance of the pharmacist. In the olden times the subscription was frequently quite lengthy, minute details of the compounding being written in choice Latin, but as present the subscription is usually boiled down to the succinct "M" or M ft. pil." or "F. S. A." These terms are left untranslated, that the student may hunt up the abbreviations in the list of Latin terms found on a subsequent page.

The *signa* represents the directions to the patient, which directions are to be written on the label by the pharmacist, translating from Latin to English, if the physician gives the directions in the former language. Like the subscription, the signa was formerly written by the physician in Latin, but the modern medical man, not being as much at home with the classics as were his predecessors, rarely resorts to Latin, except a few time-worn abbreviations found in the list of Latin terms.

The modern physician, alas! pays but little attention to his prescription, and there is no part of the curriculum of medical colleges more neglected than the very important branch of prescription writing. It is sadly true that one reason why so many young physicians have gotten into the pernicious practice of prescribing ready-made nostrums is because of their lack of knowledge of correct prescription writing.

The pharmacist should do all in his power to dissuade the physician from reducing his "signa" to the sterotyped "as directed," since the dosage should appear on the label for the guidance of the patient, and on the prescription that the pharmacist may determine if the dose is safe. While on the question of dosage, menion should be made of the need of adoption, in this country, of the system regulating large doses that is in vogue in Germany. In that country an authoritative list of maximum doses is published, and any physician desiring to prescribe a dose larger than the maximum declares his intention by underscoring the dose, or rewriting the quantity in words.

As shown above, the ideal prescription is written in the Latin language, which is used because it is the universal language of science; because it lessens the use of local synonyms; and because it is frequently advisable to keep the patient from knowing the nature of the medicine prescribed.

Concerning the value of Latin as the universal language of science, suppose an actual case and imagine we have before us three prescriptions —one of an American practitioner, one written by a physician of Hanover, Germany, and the last the order of a doctor practising in Budapest, Hungary. Quite likely the pharmacist knowns nothing of German, almost certainly he is not acquainted with the weird Hungarian tongue, yet were all three prescriptions brought to his store, he could read one as easily as the other, for all are written in Latin.

The other great value of the use of Latin is that it practically does away with the use of confusing synonyms. A person comes into a drugstore and asks for "chamomile," and the pharmacist has to inquire "which chamomile—German or Roman." Even so would it be if the doctor wrote his prescription in English and demanded "extract of chamomile." The question would again be, "which chamomile?" while if he writes "ext. anthemidis," or "ext. matricariæ," the chamomile he wants is very plain.

PRESCRIPTION LATIN

In the brief space of one chapter, much idea of Latin cannot be given, but the following explanations may throw at least some light on the Latin prescriptions.

In most English grammars we find that nouns are said to have three "cases"—nominative, possessive, and objective. Latin nouns have six such cases, but of these only two are used to any extent in pharmacy—the nominative and the genitive.

Those who have studied English grammar at all, will remember that the nominative case means that form of noun or pronoun used as the subject of the verb; thus, "John" is nominative in the sentence "John runs;" likewise "I" in the sentence "I walk." In English the form of the noun is the same, regardless of its case. Not so, however, with pronouns, for while "I" is nominative, "me" is its objective form. Latin nouns have a different ending for each case, just as English pronouns differ according to case. Having thus described the nominative, we can turn to the genitive case, which has no exact counterpart in English. It comes nearest to our possessive case, but it really means what we would put in English as "of the——," supplying the noun for the dash. A grouping of the terminations of the Latin noun in its various cases is called its declension, and the Latin nouns are grouped into five declensions, each having a different set of endings. Thus, in the first declension, we have—

Nominative, mensa (a table).

Genitive, mensæ (of a table).

and the plural of the same noun is

Nominative, mensæ (tables).

Genitive, mensarum (of tables).

In our limited space we cannot go beyond these few facts, and we will immediately proceed to practise the two cases as found in the Latin names of the pharmacopœia:

First, let us look up a pharmacopœial name belonging to the declension just given—the first. This we find in two words, among many others, "tinctura" and "serpentaria."

Nominative, tinctura (a tincture); serpentaria (serpentaria).

Genitive, tincturæ (of a tincture;) serpentariæ (of serpentaria).

Let us bring these together in the official name, tincture *of* serpentaria, which in Latin is tinctura serpentari*æ*.

In the second declension we find two forms of nouns—masculine nouns ending in "us," and neuter nouns ending in "um." They are declined:

Nominative,	us	um
Genitive,	i	i

Let us apply these terminations, first picking out some official noun ending in "us;" for instance, "syrupus" and "rubus:"

Nominative, syrupus (syrup); rubus (blackberry).

Genitive, syrupi (of syrup); rubi (of blackberry).

Combining these to read "syrup *of* blackberry," we get "syrupus rub*i*."

Among the official nouns ending in "um," we find "unguentum" and "iodum."

Nominative, unguentum (ointment); iodum (iodine).

Genitive, unguenti (of ointment); iodi (of iodine).

Then the official name of "ointment *of* iodine" is "unguentum iod*i*." Of course, we can combine nouns of any declension, only being careful to employ the correct termination. Thus, we can write "tinctura iod*i*" (tincture *of* iodine) or "syrupus serpentari*æ*" (syrup *of* serpentaria).

The third declension embraces all those nouns whose genitive ends in "is." The nominative varies greatly, causing the declension to be complex, but all the pharmacopœial variations will be given here:

Nominative.	*Genitive.*
Adeps (lard).	Adipis (of lard).
Macis (mace).	Macis (of mace).
Sulphas (a sulphate).	Sulphatis (of a sulphate).
Sulphis (a sulphite).	Sulphitis (of a sulphite).
Mucilago (a mucilage).	Mucilaginis (of a mucilage).
Nux (a nut).	Nucis (of a nut).
Liquor (a solution).	Liquoris (of a solution).
Rhus (rhus).	Rhois (of rhus).
Flos (a flower).	Floris (of a flower).
Theobroma (theobroma).	Theobromatis (of theobroma).
Cantharis (cantharides).	Cantharidis (of cantharides).

In "rhus" we have a noun ending in "us" which does not belong to the second declension, and likewise the entire fourth declension ends in "us." Fortunately, there are but two pharmacopœial names involved in this declension; they being "spiritus" and "fructus," which are declined as follows:

Nominative, spiritus (a spirit). *Genitive,* spiritus (of a spirit).
" fructus (a fruit). " fructus (of a fruit).

To sum up, all pharmacopœial nouns ending in "um" take the termination "i" in the genitive; those in "a" in the nominative—except theobroma—take "æ" in the genitive; and all ending "us" in the nominative—except rhus, fructus, and spiritus—take "i" in the genitive; these rules applying only to the singular number.

Concerning the plural, we need only consider that of the first, second, and third declensions, exemplified in "herba," "folium," and "flos" respectively.

SINGULAR.		PLURAL.	
Nominative.	*Genitive.*	*Nominative.*	*Genitive.*
Herba (an herb).	Herbæ (of an herb).	Herbæ (herbs).	Herbarum (of herbs).
Folium (a leaf).	Folii (of a leaf).	Folia (leaves).	Foliorum (of leaves).
Flos (a flower).	Floris (of a flower).	Flores (flowers).	Florum (of flowers).

So far we have considered the subject only in the simple relationship as seen in pharmacopœial names, and to make the matter still more clear, we will cite a few names where the application of the declensions may be seen:

Quini*nae* sulph*as*,	Sulphate *of* quinine.
Sod*ii* sulph*is*,	Sulphite *of* sodium.
Mucila*go* acaci*æ*,	Mucilage *of* gum arabica.
Tinctur*a* nuc*is* vomic*æ*,	Tincture *of* nux vomica.
Liquo*r* calc*is*,	Solution *of* lime.
Fluidextract*um* rh*ois* glabr*æ*,	Fluidextract *of* rhus glabra.
Spirit*us* æther*is*,	Spirit *of* ether.
Tinctur*a* belladonn*æ* foli*orum*,	Tincture *of* belladonna leaves.
Tinctur*a* arnic*æ* flor*um*,	Tincture *of* arnica flowers.
Tinctur*æ* herb*arum* recent*ium*,	Tincture*s* *of* fresh herb*s*.

("Recentium" is an adjective, genitive plural, from the nominative singular "recens," and genitive singular "recentis.")

The official (or the Latin nominative singular) of "nux vomica," "rhus glabra,", and "sodium" are the words just given.

We are now ready to consider the changes the Latin name undergoes in writing the prescription—a change that is quite marked, though very simple.

The sign ℞ means "take" and nothing else, and in the prescription we are not supposed to write—

"Take, sulphate of quinine," but, "Take, *of* sulphate of quinine," which means that in translating the prescription into Latin the word "sulphate" is put into the genitive, the same as is the word "quinine," and when correctly written, the term will stand—

"℞. Quininæ sulphat*is*"
Take *of* sulphate *of* quinine (reversed, you see) and *not*—
"℞. Quininæ sulpha*s*"
Take sulphate *of* quinine.

This is the only change in writing the pharmacopœial name in a prescription, although sometimes this change is perplexing; thus we write:

℞. Mucila*ginis* *acaciæ* and *not* ℞. **Mucila*go* *acaciæ***
(*of* mucilage *of* acacia) (mucilage *of* acacia).

Besides the nominative and genitive cases, the *ablative* case is used occasionally in pharmacopœial titles. Even as the genitive is used after the preposition "of," so the ablative is used after the prepositions "from," "with," "in," and "by." The following are the pharmacopœial instances of the ablative:

Hydrargyrum cum creta—mercury with chalk. In this case "creta" is the ablative singular of noun of the first declension, creta.

Emulsum olei morrhuæ cum hypophosphitibus—emulsion of cod-liver oil with hypophosphites. In this case "hypophosphitibus" is the ablative plural of the noun of the third declension, hypophosphis.

Ferri hydroxidum cum magnesii oxido—hydrated oxide of iron with oxide of magnesium. In this case "oxido" is the ablative singular of the noun of the second declension, oxidum.

The above outline refers only to Latin nouns. *Adjectives* change number and case with the noun they qualify, but their terminations do not necessarily conform with the termination of the noun. Thus, a masculine noun of the third declension may be qualified by a masculine adjective of the second declension. It simply changes to the same gender and case. Therefore it might be well to insert a list of adjectives found in pharmacopœial titles with their declensions:

First and Second Declensions

Singular.

	Masculine.	*Feminine.*	*Neuter.*
Nominative—	adhesivus	adhesiva	adhesivum
Genitive—	adhesivi	adhesivæ	adhesivi

Plural.

	Masculine.	*Feminine.*	*Neuter.*
Nominative—	adhesivi	adhesivæ	adhesiva
Genitive—	adhesivorum	adhesivarum	adhesivorum.

Adjectives of this class found in present and past pharmacopœial titles are:

Adhesivus	in emplastrum adhesivum	(adhesive plaster).
Amarus	in aurantium amarum	(bitter orange).
	in amygdala amara	(bitter almond).
	in vinum ferri amarum	(bitter wine of iron).
Ammoniatus	Tinctura guaiaci ammoniata	(ammoniated tincture of guaiac).
Benzoinatus	in adeps benzoinatus	(benzoinated lard).
Camphoratus	in tinctura opii camphorata	(camphorated tincture of opium).
Cantharidatus	in collodium cantharidum	(cantharidal collodion).
Citratus	in caffeina citrata	(citrated caffeine).
Compositus	Tinctura cinchonæ composita and a number of others.	(compound tincture of cinchona).
Corrosivus	in hydrargyri chloridum corrosivum.	(corrosive chloride of mercury).
Deodoratus	in tinctura opii deodorata	(deodorized tincture of opium).
Despumatus	in mel despumatum	(clarified honey).
Destillatus	in aqua destillata	(distilled water).
Dilutus	in acidum sulphuricum dilutum and a number of others	(diluted sulphuric acid).
Expressus	in oleum amygdalæ expressum	(expressed oil of almond).
Exsiccatus	in alumen exsiccatum	(exsiccated alum).
	in ferri sulphas exsiccatus	(exsiccated sulphate of iron).
	in sodii phosphas exsiccatus	(exsiccated phosphate of sodium).
Flavus	in hydrargyri oxidum flavum	(yellow oxide of mercury).
Fusus	in argenti nitras fusus	(fused nitrate of silver).

Granulatus	in ferri sulphas granulatus	(granulated sulphate of iron).
Lotus	in sulphur lotum	(washed sulphur).
Mitigatus	in argenti nitras mitigatus	(mitigated nitrate of silver).
Monohydratus	in sodii carbonas monohydratus	(monohydrated carbonate of sodium).
Ponderosus	in magnesii oxidum ponderosum	(heavy oxide of magnesium).
Præcipitatus	in ferri sulphas præcipitatus and others	(precipitated sulphate of iron).
Reductus	in ferrum reductum	(reduced iron).
Saccharatus	in ferri carbonas saccharatus	(saccharated carbonate of iron).
Stypticus	in collodium stypticum	(styptic collodion).
Sublimatus	in sulphur sublimatum	(sublimed sulphur).
Sulphuratus	in calx sulphurata	(sulphurated lime).

The adjective *ruber* (example hydrargyri oxidum rubrum—red oxide of mercury) has same endings in the nominative and genitive cases as the other adjectives of the first and second declensions, except that the masculine nominative singular is ruber.

THIRD DECLENSION OF ADJECTIVES

	Singular.		*Plural.*	
	Masculine and Feminine.	*Neuter.*	*Masculine and Feminine.*	*Neuter.*
Nominative—	Animalis	animale	animales	animalia
Genitive—	Animalis	animalis	animalium	animalium.

Adjectives of this class found in past and present pharmacopœial titles are:

Animalis	in carbo animalis	(animal charcoal).
Dulcis	in amygdala dulcis	(sweet almond).
Flexilis	in collodium flexile	(flexible collodion).
Glacialis	in acidum aceticum glaciale	(glacial acetic acid).
Levis	in magnesii oxidum levis	(light oxide of magnesium).
Mitis	in hydrargyri chloridum mite	(mild chloride of mercury).
Mollis	in sapo mollis	(soft soap).
Solubilis	in ferri phosphas solubilis and several others	(soluble phosphate of iron).

Some adjectives of the third declension have a slightly different form, viz.:

	Singular.		*Plural.*	
	Masculine and Feminine.	*Neuter.*	*Masculine and Feminine.*	*Neuter.*
Nominative—	adjuvans	adjuvans	adjuvantis	adjuvantia
Genitive—	adjuvantis	adjuvantis	adjuvantium	adjuvantium.

Three of these are used in pharmacopœial titles:

Adjuvans	in elixir adjuvans	(adjuvant elixir).
Effervescens	in pulvis effervescens compositus	(compound effervescent powder).
Recens	in tincturæ herbarūm recentium	(tinctures of fresh herbs).

Three pharmacopœial titles have the adjective in the comparative degree:

Aqua ammoniæ fortior	(stronger ammonia water).
Aqua aurantii florum fortior	(stronger orange flower water).
Aqua rosæ fortior	(stronger rose water).

Verbs are not used much in modern prescription writing beyond the stereotyped abbreviated phrases found in the list below. Moreover, a discussion of Latin verbs and their conjugation would mean a complete review of Latin grammar, which is clearly beyond the scope of this work. For further details, therefore, the reader is referred to list of books on pharmaceutic Latin found in Preface.

TABLE OF LATIN AND FOREIGN TERMS USED IN PRESCRIPTIONS

[(L.) Latin, (G.) German, (F.) French]

TERM.	ABBREVIATION.	MEANING.
Abendessen (G.),		Supper.
Ad (L.),		To, up to.
Adde (L.),	Add.	Let it be added.
Ad libitum (L.),	Ad lib.	At pleasure.
Alternis horis (L.),		Every other hour.
Ana (L.),	āā.	Of each.
Ante (L.),		Before.
Aqua bulliens (L.),	Aq. bull.	Boiling water.
Aqua fervens (L.),	Aq. ferv.	Warm water.
Aqua fontis (L.),	Aq. font.	Spring water.
Aqua pluvialis (L.),	Aq. pluv.	Rain water.
Alle drei Stunden (G.),		Every three hours.
Bene (L.),		Well, good.
Bis in die (L.),	B. i. d.	Twice a day.
Bissen (G.),		Bolus.
Bol (F.),		Bolus.
Capia (L.),	Cap.	Let the patient take.
Capsulæ amylaceæ (L.),		Starch capsules (cachets)
Charta cerata (L.),	Chart, cer.	Waxed paper.
Chartula (L.),	Cht.	Papers.
Cochleare amplum (L.),	Coch. ampl.	Tablespoonful.
Cochleare magnum (L.),	Coch. mag.	
Cochleare medium (L.),	Coch. med.	Dessertspoonful.
Cochleare parvum (L.),	Coch. parv.	Teaspoonful.
Coletur (L.),		Let it be strained.
Collyrium (L.),	Collyr.	Eye-wash.
Coquetur (L.),	Coq.	Let it be boiled.
Coucher (F.),		Bedtime.
Cuillerèe a cafe (F.),		Teaspoonful.
Cuillerèe a soupe (F.),		Tablespoonful.
Detur (L.),	Det.	Let it be given.
Dentur (L.),	Dent.	
Dentur talis dosis (L.),	Dent. tal. dos.	Give of such doses.
Deux (F.),		Two.
Dies (L.),	D.	Day.
Dividatur (L.),	Divid.	Let it be divided.
Dosis (L.),		A dose.
Drachma (L.),	ʒ	A drachm.
Drei mal täglich (G.),		Three times a day.
Ejusdem (L.),		Of the same.
Enemata (L.),	Enem.	Enema.
Esslöffelvoll (G.),		Tablespoonful.
Et (L.),		And.
Ex modo prescripto (L.),	E. m. p.	As prescribed. As directed.
Fiat (L.),	Ft.	Let it be made.
Fois (F.),		Time.
Gouttes (F.),		Drops.
Granum (L.),	Gr.	Grain.
Guttæ (L.),	Gtt.	Drops.
Hora (L.),		An hour.
Hori somni (L.),	Hor. som.	At bedtime.
Jeder or jeden (G.),		Every.
Latwerge (G.),		Electuary.
Mica panis (L.),	Mic. pan.	Crumb of bread.
Misce (L.),	M.	Mix.
Mittagessen (G.),		Dinner (at noon).
Mitte talis dosis (L.),		Send of such doses.
Non repetatur (L.),	Non. rep.	Do not repeat.
Numero (L.),	No.	In number.
Oblate (G.),		Wafer paper.
Omni horæ (L.),	Omn. hor.	Every hour.
Omni mane (L.),	Omn. man.	Every morning.

Term.	Abbreviation.	Meaning.
Omni nocte (L.),	Omn. noct.	Every night.
Optimus (L.),	Opt.	The best.
Pain azyme (F.),		Wafer paper.
Paquet (F.),		A powder (package).
Partes æqualis (L.),	P. æq.	Equal parts.
Pastillen (G.),		Losenges.
Pillen (G.) Pilule		Pills.
Pondus civile (L.),		Avoirdupois weight.
Pondus medicinale (L.),		Apothecary weight.
Post cibo (L.),	Post. cib.	After eating.
Poudre (F.),		Powder.
Pro re nata (L.),	P. r. n.	As occasion requires (when needed).
Pulver (G.),		Powder.
Pulvis (L.),	Pulv.	A powder.
Pulvis subtillissimus (L.),	Pulv. subtil.	Very smooth powder.
Quantum sufficit (L.),	Q. s.	Sufficient quantity.
Quotidie (L.),		Daily.
Repetatur (L.),	Rept.	Let it be repeated.
Rotula (L.),		Globules.
Schlafengehen (G.),		Bedtime.
Scrupulus (L.);	℈	A scruple.
Secundum artem (L.),	S. a.	According to art.
Sesqui (L.),		Once and a half.
Signetur (L.),	Sig.	Let it be marked.
Solvetur (L.),	Solve.	Let it be dissolved.
Spiritus Vini Rectificata (L.),	S. V. R.	Alcohol.
Spiritus Vini Tenuis (L.),	S. V. T.	Diluted Alcohol.
Tabella (L.),	Tab.	A losenge.
Talis (L.),		Of such.
Ter (L.),		Thrice.
Ter in die (L.),	T. i. d.	Thrice daily.
Tere bene (L.),		Rub well.
Theelöffelvoll (G.),		Teaspoonful.
Toutes les heures (F.),		All the hours (every hour).
Trois fois par jour (F.),		Three times a day.
Tropfen (G.),		Drops.
Uncia (L.),	℥	An ounce.
Ut dictum (L.),	Ut. dict.	As directed.
Zwei (G.),		Two.

For a more complete list of Latin terms, see Scoville's "Art of Compounding."

While on the subject of abbreviations, mention should be made of the danger likely to arise from the careless writing of abbreviated names of drugs. Among classic instances of such abbreviations are "hyd. chlor," which might mean chloral hydrate, mercuric chloride, or mercurous chloride; "liq. mag," which might mean solution of some magnesium salt, or else Magendie's solution (p. 821), while "sulph." may mean sulphate, sulphite, or sulphide; "nit." may mean nitrate or nitrite, and similarly an abbreviation of name of any negative element in salts and acids can be misconstrued when there is more than one acid derived from the element. In most cases of such abbreviation the experienced pharmacist can discern the remedy desired either by the dose prescribed or by the relative popularity of the several possibilities. Thus, a prescription calling for "zinc sulph." almost invariably means zinc sulphate, as the sulphite and sulphide of that metal are rarely used in medicine.

In U.S.P. IX, "sulph" is given official sanction as the proper abbreviation for "sulphate"; "sulphite" is directed to be written in full, while the abbreviation of "sulphidum" is "sulphid."

The *quantities* used in prescription writing are those of the apothec as shown in the typical prescription printed below. The metric sys is used exclusively by the physicians of continental Europe, and t slight extent by American physicians. The quantities are prefer expressed as shown in the prescription given below:

℞.	Quininæ sulphatis	2.00
	Ferri reducti	1.00
	Acidi arsenosi	0.05

Misce fiat pilulæ numero xx.

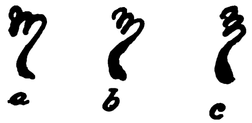
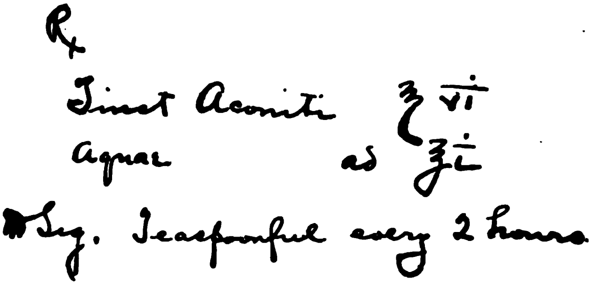


Fig. 250.—Faulty minim sign.

In this country prescription blanks are sometimes printed wit vertical line intended to separate the grammes from the fracti

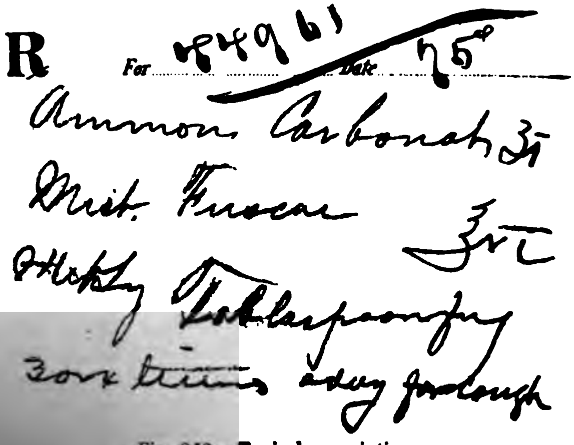


℞

Tinct Aconiti ʒ vi
Aquae ad ℥ i
Sig. Teaspoonful every 2 hours

Fig. 251.—Dangerous prescription.

parts thereof, thus replacing the decimal points in the above precripti just as in a ledger a line is used to separate dollars from cents.



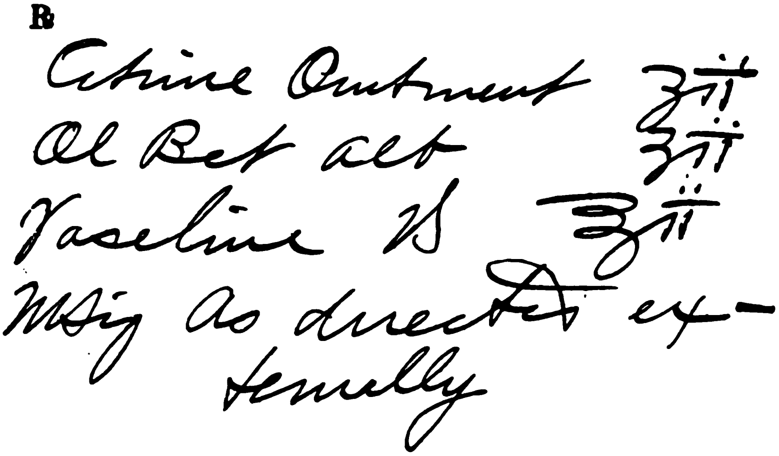
R For 84961 Date 75
Ammon Carbonat ʒi
Mist Fuscae ℥vi
Sig Tablespoonful
3 or 4 times a day for cough

Fig. 252.—Typical prescription.

Rarely does the continental physician write the word "gramme;" quantities, as written above, being clearly understood as meaning th metric system.

As abbreviations of drug names may sometimes lead to dangerous results through misinterpretation, so occasionally the abbreviations for quantities prove a source of error.

It is easy to write the symbol of ounce (℥) when drachm (ʒ) is intended, and there is still another danger lurking in the minim (♏) sign—a misunderstanding that resulted in the death of two persons in New Orleans some years since.

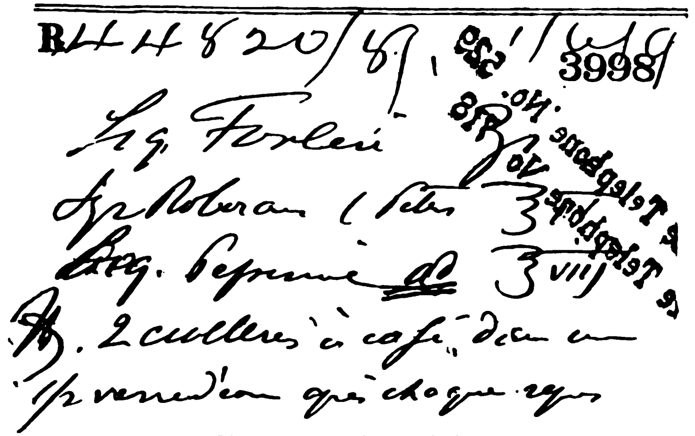


℞
Citrine Ointment ʒii
Ol Bet alb ℥ii
Vaseline W ℥ii
M Sig As directed externally

Fig. 253.—Typical prescription.

The minim sign seems distinct enough, but a prominent physician, now dead, gradually modified his minim sign from the correct form to one similar to the symbol for the drachm.

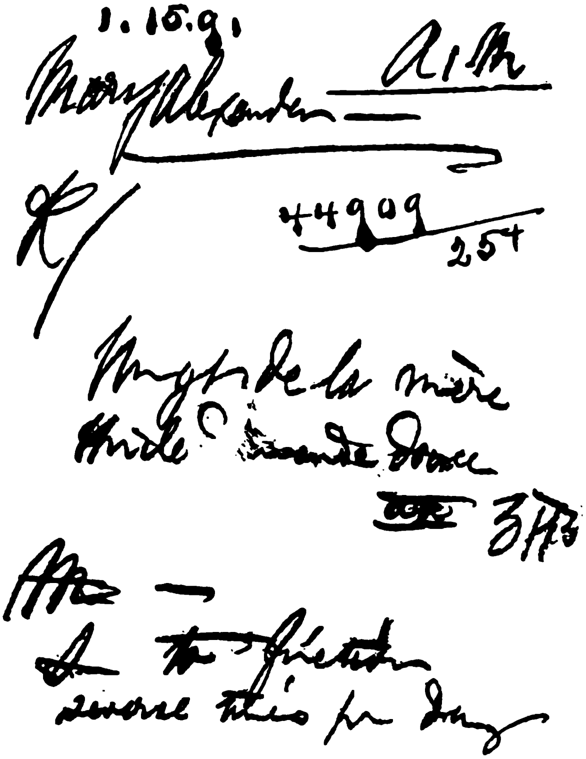
One day the physician wrote the prescription shown below, and the unfortunate druggist, in one of those frightful lapses that might come to any of us, read and dispensed *six drachms* of tincture of aconite instead of the *six minims* desired. Of course he was to blame, but when we hear of such things we should feel thankful that we were spared the fearful blunder. Naturally, the patient died, and the druggist, completely ruined, after a year of hopeless attempts of retrieving his fortune, gave up the conflict and committed suicide.



℞ 44820/87
3998
Liq. Fowleri [illegible]
Syr. [illegible] ʒ [illegible]
[illegible] ʒ viij
ft. 2 cuillerées à café dans un
1/2 verre d'eau [illegible]

Fig. 254.—French prescription.

The metric quantities as written above are less likely to mislead, although a fly-speck might be mistaken for a decimal point. Another



1.15.91

Mary Alexander [illegible]

R/ 44909 / 25¢

Magn. de la mère

Huile [illegible] douce

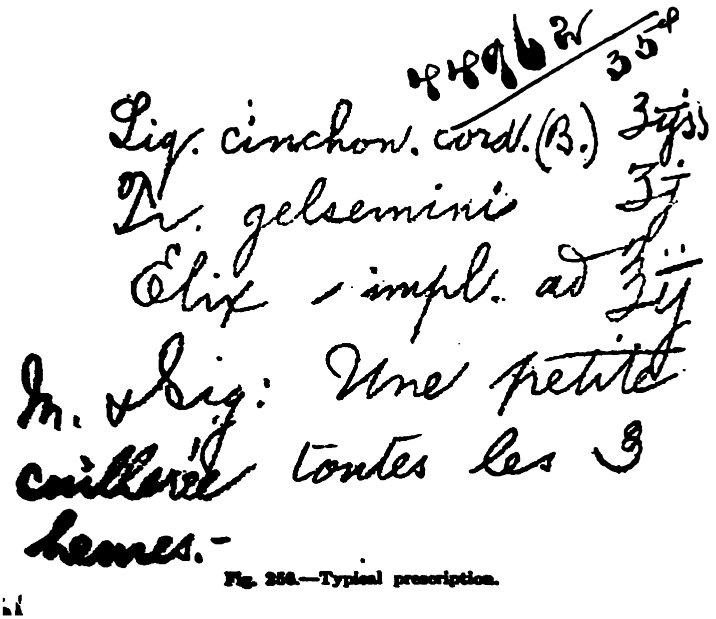
[illegible] ʒiiss

Mix —

[illegible] prescription

renew this for [illegible]

Fig. 255.—French prescription.



48962 / 35¢

Liq. cinchon. cord. (B.) ℥iss

Tr. gelsemini ʒj

Elix. simpl. ad ℥ij

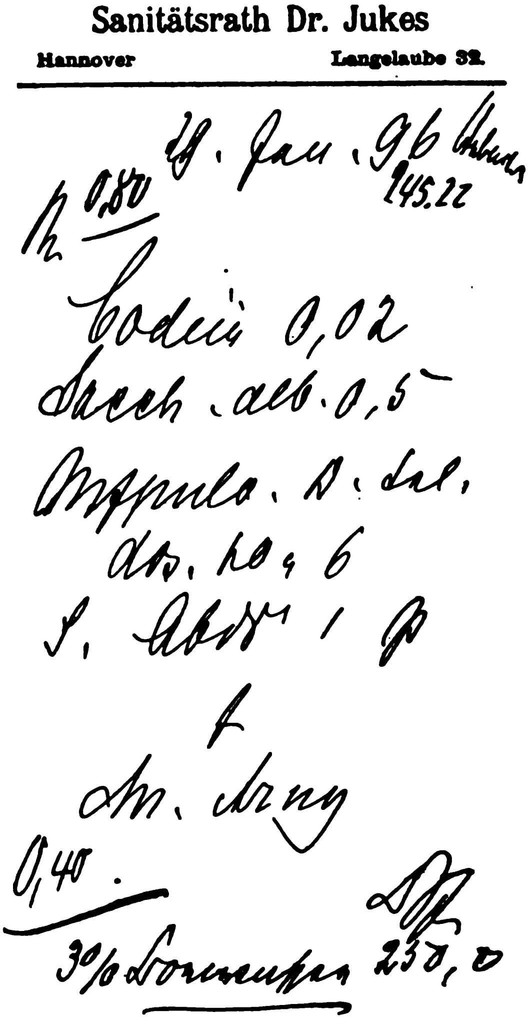
M. & Sig: Une petite cuillerée toutes les 3 heures.—

Fig. 256.—Typical prescription.

possibility of danger with physicians unfamiliar with the system is writing ten times the quantity intended. For instance, writing 0.05 (five centigrammes) when 0.005 (five milligrammes) was intended.

Before leaving the subject of the prescription as a document a few typical prescriptions may be of service.

This is a clearly written prescription of a southern practitioner.



Sanitätsrath Dr. Jukes
Hannover Langelaube 32.

14. Jan. 96 [illegible]
145.22
Rp. 0,80
Codeini 0,02
Sacch. alb. 0,5
[illegible] D. tal.
dos. No. 6
S. Abds 1 P.
[illegible]
0,40
3% Borwasser 250,0

Fig. 257.—German prescription.

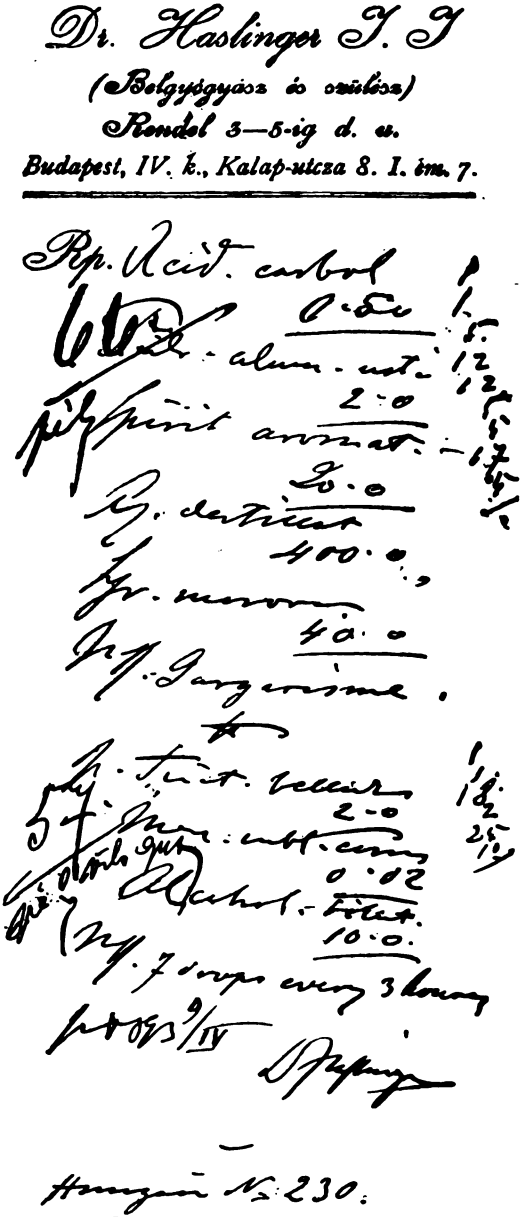
As already explained, on p. 257, *mistura fusca* is a local synonym for brown mixture.

This is an equally clear prescription, written by a northern practitioner. What is "Ol. Bet. Alb.?"

This, written by a Creole practitioner for a Creole patient, calls for Fowler's solution, a proprietary, "syrupus roborans," and the Solution of Pepsin, U.S.P. 1880. The French directions are translated into English below:

2 cuillerèes a cafè dans un ½ verre d'eau apres chaque repas.
2 teaspoonfuls in half glass of water after each meal.

Figure 255 is written by a Creole physician for an American patient. The French ingredients are: Unguent de la mêre (Unguentum Fuscum N.F.) and huile d'amande douce (oil of sweet almond).



Dr. Haslinger J. J
(Belgyógyász és szülész)
Rendel 3—5-ig d. u.
Budapest, IV. k., Kalap-utcza 8. I. em. 7.

Rp. Acid. carbol
0·50
[illegible] alum. ust.
2·0
Spirit aromat.
20·0
Gly. [illegible]
400·0
Aq. [illegible]
40·0
M. f. Gargarisme.

Rp. Tinct. bellad.
2·0
Morph. [illegible]
0·02
Alcohol. dilut.
10·0
M. 7 drops every 3 hours
Pest 1893 9/IV

Hungarian No. 230.

Fig. 258.—Hungarian prescription.

Figure 256 is a clearly written prescription with French directions. Liquor Cinchonæ Cordifoliæ (B) is a special liquid extract of cinchona prepared by Battley and Co., of England. The English translation of directions is given below: Une petite cuillerèe toutes les 3 heures. A teaspoonful every 3 hours.

Figure 257 is written by a physician of Germany, calling for six powders (dent. tal. dos.), each containing 2 centigrammes of codeine and a half gramme of sugar. The directions read:

Abends ein Pulver.

Evenings a powder.

It being characteristic of the German prescription that the time of administration is written before the dose.

An interesting illustration of the convenience of the use of Latin in prescriptions is shown when the first and second prescriptions on Fig. 257 are compared. The first, written in Latin, could be compounded by any educated pharmacist in any part of the world. On the other hand, the second, written in German, is apt to prove a puzzler. It reads: 3 per cent. Borwasser, 250 mils.
That is, a 3 per cent. aqueous solution of boric acid is desired.

The prescriptions on Fig. 258 were written by a German physician residing in Buda-Pest, Hungary, and both can be deciphered by a practised prescriptionist. For this reason they will not be translated by the writer. Mention, however, might be made of the figures on the right-hand side of the paper. In Germany, Austria, and Hungary, the price of every drug used in prescriptions, as well as the cost of containers and value of time spent in compounding, is carefully regulated by the government, and the figures above mentioned represent the summing up of values from the official schedule. Figures 259, 260 and 261 are typical prescriptions written by physicians of New York City.

CHAPTER LVIII

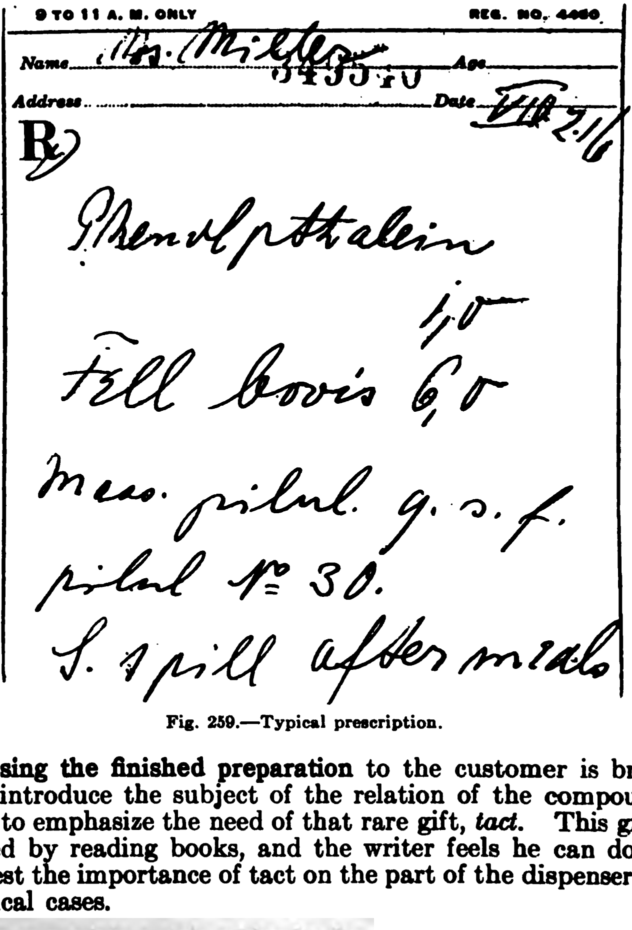
COMPOUNDING OF PRESCRIPTIONS

The prescription as a document is interesting, but of far greater importance is it that the pharmacist knows how to handle the prescription when it becomes his duty to compound it.

The work of the compounder of the prescription is manifold. He must know how to receive the prescription from and dispense the finished preparation to the customer; he must know how to label the container correctly; he must know how to fill the prescription; he must know how to scan it carefully for errors; and, lastly, he must know how to prepare or put up the medicine called for. To perform each step properly he must be intelligent, alert, tactful, skilful, careful, conscientious, and well informed.

Receiving the Prescription.—As mentioned above, if the prescription does not bear the name of the patient, the compounder should supply the deficiency, explaining it is a part of the system whereby mistakes are prevented. Cases are on record where fatal results have resulted from giving a properly prepared prescription to the person for whom it was not intended. This is most liable to occur if two persons are waiting for prescriptions written by the same doctor—say one for internal use; the other for a liniment. Hence the fact that the pharmacist hands the customer "Dr. Blank's prescription" is not a sufficient safeguard, since there may be two of Dr. Blank's prescriptions being compounded at the same time.

In large stores the giving of checks to the person leaving the prescription is a safeguard against such mistakes. A form for such checks is shown below, the one section being given to the customer, one attached to the prescription, and the third attached to the package (Fig. 262). A simpler method is giving the customer a numbered brass check and writing same number on prescription and package. Safest of all, however, is the securing of name and address of patient.



9 TO 11 A. M. ONLY REG. NO. 4460

Name Mr. Miller 34350 Age

Address Date VIII 2.16

℞

Phenolphthalein 1,0

Fell bovis 6,0

mass. pilul. q. s. f.

pilul No 30.

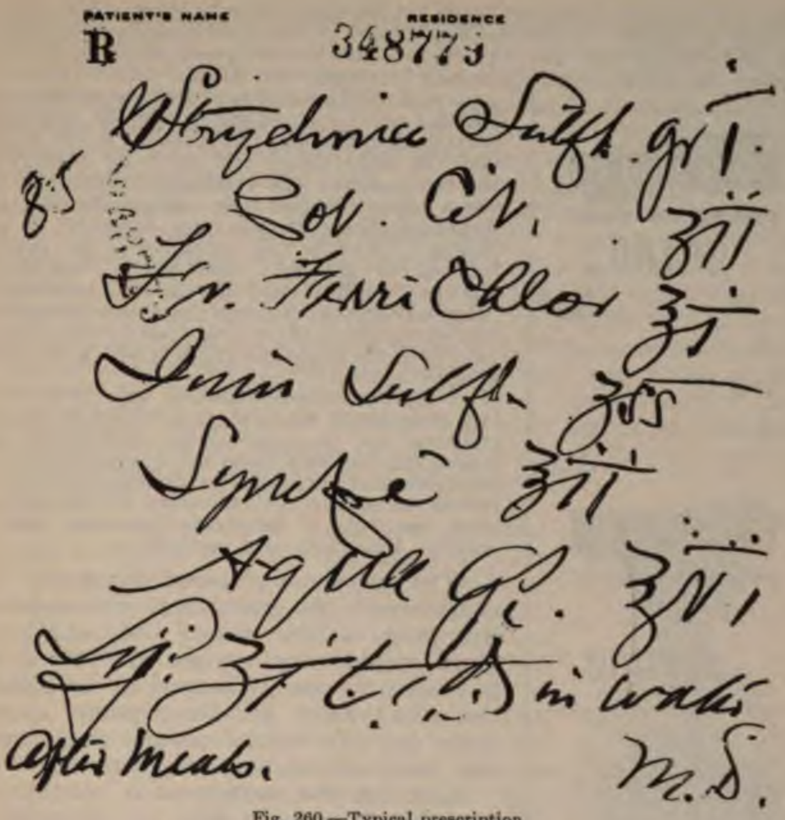
S. 1 pill after meals

Fig. 259.—Typical prescription.

Dispensing the finished preparation to the customer is brought up chiefly to introduce the subject of the relation of the compounder and dispenser; to emphasize the need of that rare gift, *tact*. This gift cannot be acquired by reading books, and the writer feels he can do no more than suggest the importance of tact on the part of the dispenser by citing a few typical cases.

A woman comes into a store asking for five grains of calomel and five grains of *salt*. The pharmacist, realizing that a prescription had been written and not presented, lest more should be charged for the goods if furnished on a prescription than when sold on verbal order, emphasizes the possible formation of mercuric chloride in such a mixture, tactfully interrogates until the woman admits that a prescription was written, and convinces her that this prescription must have called for calomel and *soda*, and persuades her to bring the prescription.

A man comes in with a printed prescription calling for pills containing several well-known tonics, and also "jerubebin, 1 grain." Instead of telling the man that the prescription is a fraud (a statement for which the mind of the dupe is prepared by the skilfully worded circular sent by the "philanthropist" who furnishes prescriptions



PATIENT'S NAME RESIDENCE

℞ 348773

Strychnine Sulph. gr i.

8.5 Pot. Cit. ʒii

Tr. Ferri Chlor ʒi

Quin Sulph. ʒss

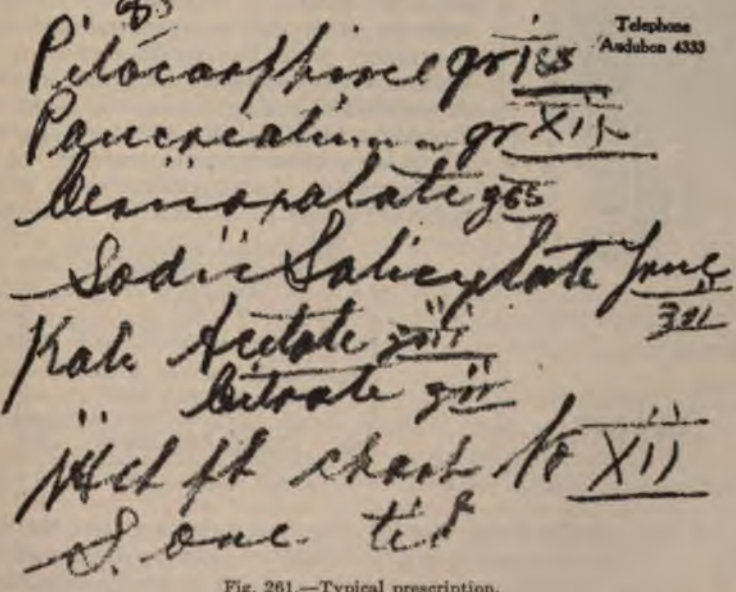
Syrupe ʒii

Aqua q.s. ʒvi

Sig. ʒi t.i.d. in water after meals.

M.D.

Fig. 260.—Typical prescription.



8.3

Telephone
Audubon 4333

Pilocarpine gr i/8

Pancreatin gr xii

Desmopalate ʒss

Sodii Salicylate ʒii

Kali Acetate ʒii

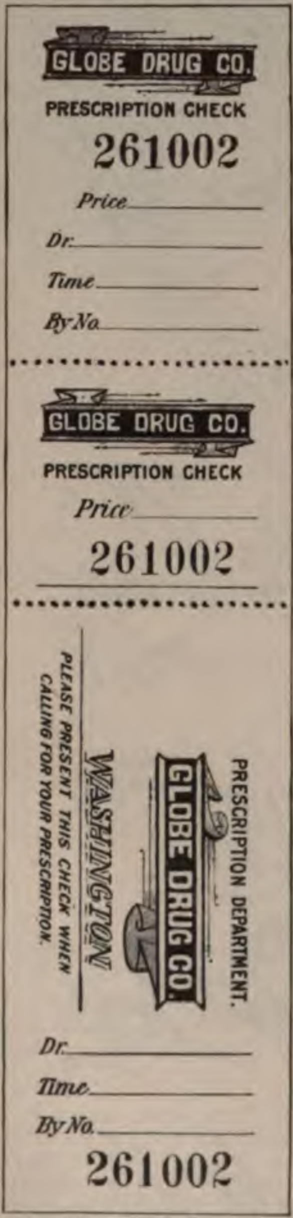
" Citrate ʒii

M et ft chart No XII

S. one t.i.d.

Fig. 261.—Typical prescription.

"free"), the pharmacist quietly brings out Druggists' Circular (1884, p.138), in which the fraud is exposed. The testimony afforded by this disinterested source convinces even the credulous chap who is saved the dollar he was to send the donor of the prescription "in case the medicine cannot be obtained elsewhere."


GLOBE DRUG CO.
PRESCRIPTION CHECK
261002
Price
Dr.
Time
By No.

GLOBE DRUG CO.
PRESCRIPTION CHECK
Price
261002

PRESCRIPTION DEPARTMENT.
GLOBE DRUG CO.
WASHINGTON
PLEASE PRESENT THIS CHECK WHEN CALLING FOR YOUR PRESCRIPTION.
Dr.
Time
By No.
261002

Fig. 262.—Prescription check.

A man who once had a prescription wrongly compounded insisted on sitting behind the prescription counter watching the compounder, so as to keep tab. To make things still safer, he usually plied the compounder with questions. The new clerk was a young man just from college; the man, more suspicious than ever, was more persistent in questioning. "What's this medicine?" he inquired, pointing to the then little-known abbreviation "antipy." "Oh," said the youth, nonchalantly, "that's Latin for the new medicine, phenyl-dimethyl-pyrazolon." From that day forth the man considered the youth the smartest and most reliable druggist in town.

A nervous woman wants to know what a certain prescription she holds in her hand is good for, and what are its constituents. The tactful pharmacist responds that these are questions which the physician who wrote the prescription is alone permitted to answer, and expresses his willingness to place the lady in telephonic connection with the doctor. His kindly offer is declined.

The only other phase of dispensing to be considered is the question of containers and wrapping of the same. This subject is given consideration on pp. 287–290, so here it is only necessary to say that the pharmacist who values his prescription business, picks out the best glassware, finest corks, and most refined boxes and printing.

Labeling the containers is worthy of a special paragraph, as often the effect of the choicest labels is marred by blurred or scratchy, uncouth, or overflourished writing. A severely plain, heavily shaded back hand, written with the blackest ink and allowed to dry without blotting, makes the most attractive form of label, but of late type-written labels have become quite popular. A strikingly written prescription label is given below (Fig. 263). It will be noted that the body of this label contains neither lines nor printing; that the filled-in part of label is a symmetric whole; that the printing is severely plain and as concise as possible. All the data on the label are essential; the

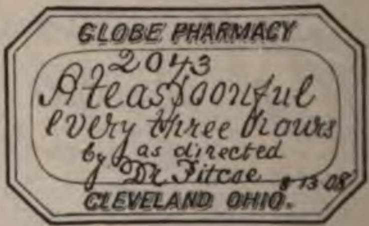

GLOBE PHARMACY
2043
A teaspoonful
every three hours
as directed
by Dr. Fitcae 8 13 08
CLEVELAND OHIO.

Fig. 263.—Typical label.

number, the name of the physician, the directions, and the date should appear on each label. In some States the law directs that the name of the compounder should be put on the container, in which event a small gummed slip, "Dispensed by—," attached to the bottom of the package or bottle usually suffices. It is an excellent practice to have labels intended for external use printed on glazed red paper, this affording a striking contrast to the white paper label for internal preparations. Then, of course, the pharmacist should be provided with slips bearing such frequently used directions "shake well;" "for external use," etc.

Filing Prescriptions.—As the prescription is more or less of a legal document, it is important that the pharmacist carefully preserves either the original or a duplicate. In this country the original is kept by the pharmacist, although the question as to who owns the prescription—the patient or the pharmacist—has been and still is a matter of legal controversy. It would be interesting if the several conflicting court opinions on this matter could be settled for once and all by a decision from the United States Supreme Court. In Germany it is the universal custom to return the prescription to the patient, the pharmacist keeping a carefully checked copy.

The first step toward preserving the prescription for future reference is giving it a number. These numbers run consecutively and are written on the prescription with date and price. One pharmacist known to the writer started new numbering each year, marking the first prescription compounded on January 1st as No. 1, stringing all the prescriptions of one year on a long piece of ⅛-in. brass wire, the files of each year being hung on a row of nails driven in the walls, each nail labeled for the year. This plan is *not* to be commended, for whenever it chanced that the date on the label was faded, it necessitated looking up the same number on possibly a dozen files.

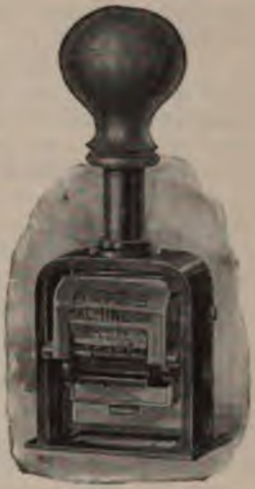


Fig. 264.—Prescription numbering machine.

Many large establishments now use consecutive numbering machines, such as the one shown in the appended cut (Fig. 264). Such machines consist of a stamping apparatus, which automatically changes the type of the numbers one unit higher each time an impression is made, thus precluding the possibility of giving two prescriptions the same number. In the more expensive varieties the same number can be repeated in duplicate (or even triplicate), thus enabling the compounder to number the prescription and label before the machine progresses one unit higher. However, the suggestion that the entire label be written renders a duplicate numbering machine unnecessary.

Several ways of preserving prescriptions are in vogue in this country.

Filing on String or Wire.—This method, outlined just above, is the least satisfactory of all others. The hole in the prescription, when pierced by the wire (or by the needle, if string is used), may cut out a part of the wording most needed. The weight of the pile of prescriptions bearing down and rubbing against a lead-penciled prescription is apt to blur it beyond recognition, while the long file hung on the wall catches dust and soon becomes filthy.

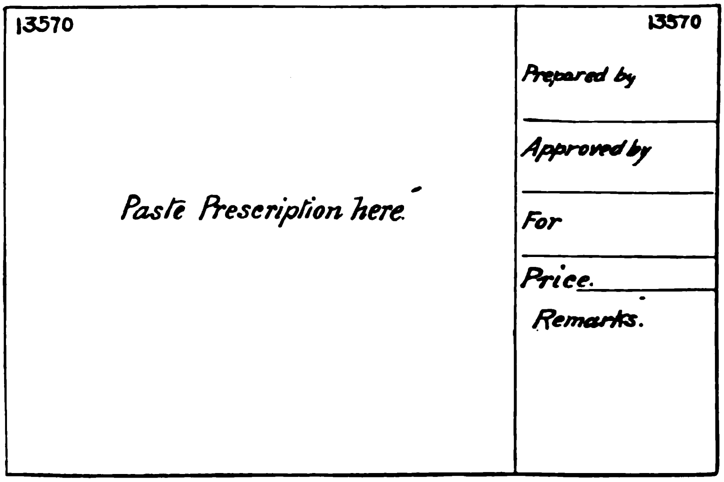
60

Pasting in a Scrap-book.—This method is quite satisfactory, although the handling and storing of big scrap-books are sometimes inconvenient.

Writing a Copy in a Blank Book and Filing or Returning Originals.—This method, used by all pharmacists of Germany and by a few prescriptionists of America, entails a large amount of work and is apt to lead to errors unless the copy is carefully checked against the original by a second person, as in proof-reading.

Wrapping the Prescriptions in Packages of 100 *and Packing Ten Consecutive Hundreds in a Wooden Box.*—This method was used by Dr. A. E. Ebert, and there are on the market one or more patented files embodying the same idea. The prescriptions are thus kept perfectly clean, but on opening a package to get the desired prescription, there is danger of the others being mislaid or blown away.

Pasting to a Card which is Filed in a Cabinet.—This method, a result of the modern filing card-cabinet craze, is by all means the most satisfactory method of filing the prescription. The best form of card is that shown below (Fig. 265), with marginal space on which all data can be written, thus leaving the prescription absolutely intact.



13570

Paste Prescription here.

13570

Prepared by

Approved by

For

Price.

Remarks.

Fig. 265.—Prescription filing card (reduced).

In event of success of the present movement looking toward the abolition of the repetition of prescriptions by the pharmacist unless so directed by the physician, the question of filing prescriptions will become less important, since in such case the prescription will be referred to less frequently.

Scanning for Errors.—This heading opens the important topic of the tact required by the pharmacist in dealing with the physician.

The pharmacist must always carefully study the prescription to note possible errors as to dosage and dangers as to incompatibility.

If such errors are found, the customer should be dismissed with some excuse and with the promise to "send it around," and the physician approached as to his real intention. This duty is the most delicate that falls to the pharmacist. If he telephones the doctor with the blunt message "Haven't you made a mistake?" he is apt to gain a life enemy. If, on the other hand, he calls on the physician, remarking something about being uncertain as to the physician's intention, casually mentioning that his construction of the prescription means a pretty stiff dose, asking if drachms were meant instead of his reading of ounces, the physician is usually glad to take this loophole of escape and will accept the question made by the druggist, inwardly deciding that the druggist possesses tact as well as knowledge. If diplomacy fails, as it sometimes does with a fool who masquerades as a professional man, rough-shod tactics should be employed, and the druggist should then—*and only then*—tell the doctor that the dose is excessive, backing his statement by printed authorities, such as the dispensatories, and declining to fill the prescription unless the doctor repeats the quantity, *written in words.*

In all cases where the doctor is in error he is quite anxious that the patient does not learn of the blunder, and in the controversy in question the pharmacist should let the doctor know that the prescription will be returned to the patient with the reason why it was not dispensed. Of course, in this case the adage "be sure you're right, then go ahead" must be religiously observed by the druggist.

Necessarily, the druggist must do everything in his power to maintain the most cordial relations with the physician, but this does not mean that he must supinely submit to injustice. A few examples of this phase of the prescriptionist's experience may be of service.

The "blind prescription," the prescription that can be put up only by a few favored druggists, is a nuisance that can and should be immediately stamped out by reporting the offenders—the doctor, to the local medical association; the pharmacist, to the local druggists' association.

Two examples of such blind prescriptions are found on p. 811, in the two names for quinine sulphate. The synonym "sulphatis Americanis Australis" was written in good faith by the physician, who desired to keep the patient from knowing she was taking quinine, and who cheerfully furnished the information to the druggist, while the doctor who perpetrated "sulphat de pelletiere" told the patient the prescription could be prepared only by a druggist blocks away, and furnished the information to the neighboring druggist only after a sharp talk.

A certain "Dr. Jones" wrote a prescription, "Dr. Jones' rheumatic mixture," telling the patient that it could be obtained at a certain remotely situated drug store. The druggist to whom it was presented called on the doctor and pleasantly asked to be favored with the recipe. It was forthwith furnished with abundant explanations.

Compounding the Prescriptions.—The preparing of each prescription is a law to itself, the blending of the ingredients called for depending entirely on the individual peculiarities of the medicines so blended. In the foregoing pages of this book information has been given of most substances used in American medicine, as well as the methods of compounding various classes of preparations. If this information has been absorbed, the compounding of prescriptions becomes simple—merely the application of principles already learned. At this place, therefore, we need only discuss the technical phases of compounding as it peculiarly applies to the prescriptions, and also the question of incompatibility.

Special Technic of Prescription Compounding.—As just mentioned, the routine compounding of a prescription calling for pills is similar to the directions given for the manufacture of pills on p. 303; for emulsions, as explained on p. 260; and for all other preparations, as outlined in the proper place on the foregoing pages. This done, the compounder should always verify his results by the so-called "*checking system;*" that is, after the prescription is compounded, the finished preparation and the written prescription are handed to the second person, while the compounder repeats the prescription, laying special emphasis on the quantity of each ingredient. This checking system should be used in every pharmacy, no matter how small. If there is but one skilled compounder in the store, he should train the boy to check for him, and if the compounder is by himself, he should check his own work by placing each bottle containing the medicine used in a row on the counter, with the weight employed immediately in front of the bottle. This precaution might be criticized as meaning an outlay for extra weights, but this expenditure is more than compensated for by the security coming from the plan.

In Case of Error.—Perhaps this title seems superfluous, since, of course, no errors should occur, but the writer agrees with an experienced pharmacist who said that whenever he heard of a druggist's mistake he simply thanked God that he was not the offender. Mistakes are liable to occur to all, hence the compounder should guard continually against errors, for even one of these may blast the pharmaceutic reputation of a life-time.

The handling of an error calls for the highest possible tact, hence no fixed and fast rules can be given, except the general statement that an attempt to explain by lying usually makes matters worse. Of course, whenever possible, the error should be repaired without exciting the suspicion of the customer, such as intercepting the messenger or requesting return of medicine, but at all hazards the damage must be repaired even if it is necessary to call the prescribing physician to your aid. This last step, disastrous as it is to the pharmacist, should be taken only in extreme cases.

INCOMPATIBILITIES

The word "incompatibility" means "lack of agreement," and when the several ingredients in a prescription do not agree, such mixture is said to be incompatible. Prescription incompatibility is grouped into three classes, according to the nature of the disagreement; *pharmaceutic* (or physical) incompatibility; *chemical* incompatibility, and *therapeutic* incompatibility. These we will consider in regular order.

Pharmaceutic incompatibility is that form of disagreement depending chiefly on the question of relative solubility. Thus a solution of resinous substance, say, tincture of ginger, will become turbid on addition of water, not because of any chemical change, but because the resin, while soluble in alcohol, is not soluble in alcohol diluted with water. Likewise, a gum in aqueous solution—like mucilage of acacia—will be precipitated on addition of a strongly alcoholic tincture, simply because the gum is insoluble in diluted alcohol. A third typical case of pharmaceutic incompatibility that might be cited is the classic prescription calling for quinine, sulphuric acid, and a licorice preparation (p. 811). The reason for giving this case special emphasis is because, at first glance, it seems a case of chemical incompatibility, since it deals with the active principle of licorice, glycyrrhizin. But since it is based entirely upon the solubility of glycyrrhizin in acid, and not with the chemical decomposition of the glycyrrhizin, it is an example of pharmaceutic incompatibility.

Among pharmaceutic incompatibilities, for the want of a better place, we group such prescription experiences as the dispensing of deliquescent salts, the compounding of pill prescriptions calling for excess of liquid, and those cases where not enough solvent is directed.

Chemical incompatibility is that form of disagreement where a chemical change occurs when two or more substances are blended. Sometimes the chemical change improves the product, and such cases are not considered as incompatibilities. An example of this is the well-known prescription calling for mercuric chloride and potassium iodide (p. 557), when a soluble potassio-mercuric iodide is formed. Such cases are rare, however, being limited to the formation of hydroxides from oxides, the neutralization of a base by an acid, and a few special reactions such as the saponification of an oil by addition of alkali.

In the modern conception of solution it is considered that chemical action usually conforms with the following rule:

A chemical reaction occurs between two soluble bodies only when one or more products of such a reaction is either insoluble or gaseous. Always apply the above rule. Thus, if NaCl and KBr be mixed, will there be a reaction? What would be the products of such a reaction? Naught but KCl and NaBr—both soluble bodies—hence no reaction occurs. On the other hand, if we added a solution of NaCl to a solution of $AgNO_3$, a reaction would occur because one of the possible reaction products—AgCl—is insoluble.

Hence the whole question hinges on the solubility of the reaction products, and the table of solubilities, given on p. 120, will be of great value in considering this question.

Among the more important cases of precipitation (hence of incompatibility) are the following:

1. *The formation of an insoluble salt, as in the case just cited.*

If Part V, dealing with chemical analysis, has been carefully studied, the most likely forms of such precipitation will have been learned, thus: (*a*) The alkaline metals, lithium, sodium, potassium, and ammonium, are hardly likely to be precipitated by any chemical (p. 407).

Exception: Potassium salts plus tartaric acid may precipitate potassium bitartrate.

(*b*) The alkaline earths—barium, strontium, calcium, and magnesium—will be precipitated on addition of carbonates and phosphates.

(*c*) The third, fourth, fifth, and sixth groups of metals will be precipitated by the carbonates, phosphates, hydroxides, and sulphides.

This statement must be taken in a general way. Thus, with several of the metals, the precipitated hydroxide is redissolved by excess of alkaline hydroxide, and, in truth, arsenic is not precipitated by hydroxide.

(*d*) The seventh group of metals—silver, lead, and mercuric salts—will be precipitated by all the foregoing, and also by chlorides and sulphates.

Besides these general rules, the special precipitants explained as tests in Part V. will, of course, act as incompatibilities.

2. *Formation of special insoluble organic salts*, such as tannate of iron (ink), when tannin-bearing drugs are combined with iron salts; meconate of lead, when opium preparations are combined with lead solutions; and the production of the insoluble blood-red iron salicylate when iron preparations are combined with salicylates.

3. *Precipitation of alkaloids by alkaloidal reagents* (p. 797). Example of this is the precipitation of the cinchona alkaloids when preparations of this drug are combined with potassium iodide and mercuric chloride.

4. *Formation of insoluble bodies when synthetic organic chemicals are combined with certain reagents.* An example of this is the formation of green crystals when antipyrine is treated with spirit of nitrous ether that has become acid.

5. *Formation of insoluble bodies when certain organic chemicals are decomposed by certain reagents*, such as the decomposition of chloral, by action of alkali, into chloroform (p. 600).

To give extended examples of these incompatibilities, beyond the outline given above and the mention made of these individual peculiarities in discussion of the chemicals in Parts III and IV, would take too much space, hence for complete enumeration of incompatibilities the reader is referred to Ruddiman's admirable work on "Incompatibilities," mentioned in Preface.

Incompatibilities due to liberation of gases may be summed up as *explosive prescriptions*, combinations where carbon dioxide is evolved with that mild form of explosion called *effervescence;* and those few cases where gaseous ammonia may be liberated from ammonium salts.

Explosive prescriptions must be known in advance by the compounder, as otherwise an explosion may occur, producing dangerous results. As already explained (p. 427) explosions are produced by a sudden evolution of gases, and all substances liable to produce such gaseous evolution on trituration must be handled with the utmost caution. Already in Parts III and IV we have learned most possibilities of this kind, so here a sketchy summary will suffice:

(*a*) All oxidizing agents, such as potassium chlorate, chromic acid, potassium permanganate, silver oxide, hydrogen dioxide, and nitric acid, are liable to explode when combined with organic matter, and such oxidizable inorganic matter as sulphur or charcoal.

(*b*) Hypophosphites are liable to explode when heated above 100°C., or when combined with any substance (such as *nitrates* and other oxidizing agents) liable to produce phosphine (PH_3).

(*c*) A modification of "*a*" is the fact that strong nitric acid and its preparations effervesce with drug preparations containing tannin and with oil of turpentine, sometimes with explosive violence.

(*d*) Iodine is liable to explode when treated with ammonia or with oil of turpentine.

Effervescent Prescriptions.—When any acid combines with a carbonate, carbon dioxide is evolved with an effervescence which is harmless if allowed to proceed in an open dish. If the ingredients are mixed in a bottle which is immediately corked, the force of the compressed gas is enough to blow out the cork or possibly shatter the bottle. Hence, as already mentioned on p. 452, such mixture should be prepared in graduate or mortar, and the liquid poured into the bottle with only a slight "bead." Aside from a clearly discernible combination of carbonate and acid, look out for prescriptions calling for carbonates and those pharmaceuticals containing acetic acid, such as syrup of squill.

Combinations Liberating Ammonia.—Such prescriptions are rare, being practically confined to combinations of ammonium chloride and lime or of solution of ammonium salts with solution of soda and solution of potassa.

Therapeutic incompatibility is that form of disagreement where the doctor prescribes two medicines that are therapeutically antagonistic. Examples of this are the blending of a stimulant with a sedative, of a mydriatic, like belladonna, with a miotic, like physostigma; of pepsin with alkali, and of pancreatin with acids. The combining of pepsin and pancreatin is also condemned by the best medical authorities.

The question of therapeutic incompatibility is entirely beyond the province of the pharmacist, the writer's experience being that the doctor, no matter how friendly, resents suggestions from the druggist along this line.

Handling Incompatible Prescriptions.—The question of the compounding and dispensing of incompatible prescriptions can best be considered in discussion of each of the several examples of incompatible prescriptions given on the pages which follow.

Discussing the subject in a general way, it can be said that the question—both as to compounding and dispensing—is a matter of good judgment.

Every pharmacist should know an explosive prescription at sight, should know those which should not be combined under any circumstances (such as chromic acid and glycerin), and those which can be mixed if proper precautions are taken (such as mixing nitric acid and oil of turpentine). Explosive prescriptions are a menace to the compounder rather than to the customer, hence self-interest behooves complete knowledge of this class of prescriptions.

In other forms of incompatibility the pharmacist is confronted with two important questions: 1. "Is the prescription safe to dispense?" 2. "How can it be least objectionally compended?"

As to dispensing, there are frequently cases of *intentional incompatibility*—cases where the doctor really desires an unsightly mixture, because of its therapeutic virtue. We all know that the official chalk mixture is of value because of the insoluble chalk it contains; even so the prescription calling for zinc sulphate and lead acetate must be dispensed containing the precipitate of lead sulphate, since that constitutes a large part of the healing effect of the mixture.

On the other hand, prescriptions in which potent medicines are produced in insoluble form, such as those prescriptions in which powerful alkaloids are precipitated, should be viewed with suspicion by the compounder, and while it is often an exceedingly delicate matter to approach the physician on the subject, it is usually best to let the doctor know, either at the time or later, the possibility of danger. No pharmacist of tact or good sense will bluntly announce to the customer that he will not compound such a prescription, but will always consult the physician. In all cases where this kind of prescription is dispensed, a "shake well" label must be put on the bottle.

Of course, there are prescriptions of this kind which must not be dispensed, such as the mixture of chloral hydrate and an alkali cited above, and in the list of prescriptions which follow mention is made of those which are unsafe to dispense.

A last word on consulting the physician about dangerous incompatibility as well as dangerous doses. Always approach him armed with accepted authority. On dosage, the two dispensatories can be cited, while on incompatibilities, Ruddiman's book is the best guide.

The question as to the best way of compounding an incompatible prescription depends on the individual prescription, and in the line of incompatible prescriptions which follow, the best way of compounding is usually given. In a general way it might be stated that when the two substances likely to react are diluted as much as possible before mixing, the chances of incompatibility are lessened, as was discussed on p. 373.

Another important question of compounding is, "When is the pharmacist justified in changing a prescription?" The answer is that a change is justified only when such change improves the prescription without affecting its medicinal action. A few examples may be cited:

(*a*) A prescription calling for a certain alcoholic tincture mixed with gummy substances may precipitate the gum. If the equivalent amount of the fluidextract is used, the precipitation may be avoided.

(*a*) An aromatic water, when used to dissolve a salt like potassium iodide, has some of its oil separate, and cloudy mixture results. If the salt is dissolved in the smallest quantity of water and then mixed with the aromatic water, no oil will separate.

(*d*) A prescription called for phenol mixed with an amount of water insufficient to dissolve it. If a part of the water—say one-eighth or one-quarter—be replaced by glycerin, a perfect solution ensues.

(*d*) Pills calling for ferrous sulphate. U.S.P., or other crystalline salts are found to yield a mass that is too soft. By use of the proportional quantity of exsiccated salt the mass can be easily made. Most of these or similar cases are given among the prescriptions cited on the pages which follow, so this short summary suffices at this place.

Inadvisablei s it, however, to make a construction like that cited on p. 955, that an unsightly prescription calling for "magnesia" can be made sightly by using soluble magnesium sulphate.

In conclusion let it be said that when a change is made, it is always best to let the physician know, explaining why the change was made.

ONE-HUNDRED INCOMPATIBLE, DANGEROUS OR UNUSUAL PRESCRIPTIONS

Below are printed 100 prescriptions that are sufficiently out of the ordinary to justify careful attention by the student. In order to afford students practice, the criticisms are not given along with each prescription, but are found on pp. 959 to 964.

1. ℞. Tinct. iodi.......... ʒij
Liniment. ammoniæ.......... ℥iv.
M. Ft. lint.

2. ℞. Spiritus ætheris nitrosi.......... ℥ss
Fluidext. uvæ ursi.......... ℥iss.
M. Sig.—Teaspoonful every four hours.

3. ℞. Acidi chromici.......... gr. x
Glycerini.......... ℥ss.

4. ℞. Olei terebinthinæ.......... ℥iv
Acidi nitrici.......... ʒiv.

5. ℞. Argenti oxidi.......... gr. v.
M. Ft. pilulæ No. xx.

6. ℞. Zinci oxidi.......... ʒij
Zinci carb. præc.......... ʒj
Petrolati.......... ʒss
Liq. calcis..........ad ℥iv.

7. ℞. Quin. sulphatis.......... gr. x
Potass. acetatis.......... gr. xx
Acidi sulphurici.......... gtt. x
Aquæ..........q.s. ad ℥ij.

8. ℞. Tincturæ cinchonæ.......... ℥iss
Tincturæ guaiaci.......... ℥ss
Mucilaginis acaciæ.......... ℥iss.

9. ℞. Ammonii carbonatis.......... gr. xxiv
Ferri et ammon. cit.......... ʒj
Glycerini.......... ℥ss
Aquæ..........ad ℥viij.

10. ℞.	Copaibæ		ʒj
	Acid. sulph. arom		ʒss
	Inf. rosæ	q.s. ad	℥iij.
11. ℞.	Morphinæ sulphatis		gr. ij
	Spt. æth. nit		℥ss
	Aquæ	ad	℥vj.
12. ℞.	Hydrarg. chlor. corrosivi		gr. j
	Sodii boratis		gr. v
	Aqua destillatæ		ʒiv.
13. ℞.	Potass. cyanidi		gr. j
	Acidi citrici		gr. v
	Syrupi pruni virg		℥iv.
M.	Dessertspoonful.		
14. ℞.	Ammonii chloridi		ʒj
	Calcis		ʒiij
	Aquæ		℥ij.
15. ℞.	Potass. brom		ʒij
	Chloralis		ʒj
	Spts. ammon. arom		℥ss
	Syrupi aurant. cort		℥ij
	Aquæ	ad	℥iv.
16. ℞.	Tincturæ iodi,	āā	℥ss.
	Collodii,		
	Aquæ ammoniæ.		
M.	Ft. sol.		
17. ℞.	Bismuthi et ammon. cit		gr. xxx
	Liquor pepsini		ʒj
	Elix. et aquæ	āā ad	℥iv.
18. ℞.	Copaibæ		℥iv
	Olei cubebæ		gtt. xx
	Calcis		gr. xx.
19. ℞.	Pilulæ colocynthidis comp		gr. xx
	Hydrargyri chlor. mit		gr. vj
	Tinct. capsici		gtt. xx.
20. ℞.	Vini ipecacuanhæ		gtt. xx
	Magnesii sulphatis		gr. xx
	Sodii bicarbonatis		ʒj
	Aquæ		℥j.
21. ℞.	Argenti nitratis		gr. v
	Micæ panis		gr. xx.
M.	Ft. pilulæ No. xx.		
22. ℞.	Potass. bromidi		ʒvj
	Aquæ camphoræ		℥vj.
M.			
23. ℞.	Tincturæ nucis vomicæ		℥ss
	Tincturæ cinchonæ comp		℥iiss.
24. ℞.	Syrupi ferri iodidi		℥iss
	Potassii iodidi		ʒj
	Potassii carbonatis		ʒiss
	Syrupi tolutani		℥ss
	Aquæ		℥ij
25. ℞.	Quininæ bisulphatis		ʒss
	Misturæ Bashami		℥ij.
26. ℞.	Potassii bromidi		ʒiv
	Aquæ menthæ piperitæ		℥vj

27. ℞.	Potassii bicarbonatis	ʒj
	Tinctura guaiaci ammoniatæ	ʒij
	Mucilaginis acaciæ	ʒij
	Quininæ sulphatis	gr. viij
	Acidi sulphuric. arom	ʒiv
	Aquæ	ad ℥iv.
28. ℞.	Tincturæ guaiaci ammoniatæ	℥ij
	Spiritus ætheris nitrosi	℥ss
	Aquæ cinnamomi	ad ℥iv.
	M.	
29. ℞.	Asafetidæ	gr. xv
	Pulveris camphoræ	gr. x
	Terebinthinæ albæ	gr. vj
	Olei menth. pip	gtt. iv.
	M. Ft. pil. No. x.	
30. ℞.	Cinchoninæ sulphatis	ʒiij
	Acidi nitrici	gtt. x
	Aquæ	℥iv.
	M.	
31. ℞.	Croton chloralis	℈iv
	Alcoholis q.s. ft. sol.	
	Mucilaginis acaciæ	℥ij.
32. ℞.	Fluidext. hamamelidis	℥ij
	Fluidext. hydrastis	℥iv.
	M.	
33. ℞.	Hydrargyri chloridi corrosivi	gr. ¼
	Strychninæ sulphatis	gr. j
	Quininæ sulphatis	ʒj
	Liquor acidi arsenosi	ʒj
	Tincturæ ferri chloridi	ʒij
	Misturæ ferri et ammon. acet	ad ℥iv.
34. ℞.	Tincturæ myrrhæ	ʒij
	Morphinæ acetatis	gr. j
	Acidi tannici	ʒss
	Syrupi Zingiberis	℥j.
	M. Ft. sol.	
35. ℞.	Hydrargyri bichloridi	gr. j
	Liq. potass. arsenitis	gtt. xlviij
	Syrupi ferri iodidi	ʒvj
	Elixir cinchonæ	ad ℥vij.
36. ℞.	Cocainæ hydrochlor	gr. ij
	Sodii boratis	gr. x
	Aquæ	℥j
	M. Ft. sol.	
	Sig.—Apply to eye.	
37. ℞.	Hydrarg. bichlorid	gr. j
	Potassii iodidi	ʒiij
	Tincturæ cinchonæ comp	℥viij.
	M. Ft. sol.	
	Sig.—Teaspoonful thrice daily.	
38. ℞.	Ammonii muriatis	ʒj
	Potassii iodidi	℥ss
	Tincturæ opii camph	℥ss
	Syrupi pruni virg	℥ij
	Syrupi tolutani	℥ij
	Aquæ	q.s. ad ℥vj.
39. ℞.	Fluidext. nucis vomicæ	♏xl
	Fluidext. digitalis	ʒiss
	Tincturæ strophanthi	℥ss
	Potassii nitratis	ʒiiss
	Elixir gentianæ et ferri	ad ℥vj.

40. ℞. Argenti nitratis........................ gr. 1/6
Bismuthi subnitratis.................... gr. ij
Ext. belladonnæ fol..................... gr. 1/12.
Dent. tales dos. No. x.

41. ℞. Quininæ bisulphatis.................... ʒj
Sodii hyposulphitis..................... ʒiiss
Glycerini.............................. ℥j
Aquæ cinnamomi....................ad ℥iv.
M.
Sig.—Shake and take a teaspoonful one hour before meals, in water.

42. ℞. Potassii iodidi
Liquor potassii arsenitis } ....āā ℥ss.

43. ℞. Potassii citratis........................ ʒiij
Potassii bicarbonatis.................... ʒiij
Tincturæ belladonnæ.................... ʒiiss
Aquæ menthæ piperitæ............q.s. ad ℥viij.

44. ℞. Ferrous sulphate........................ 5 grains
Magnesia.............................. 10 grains
Peppermint water........................ 11 fluidrachms
Spirit of nutmeg........................ 1 fluidrachm.
Mix. Of such dose, make 1 pint.
Directions.—One teaspoonful twice a day.

45. ℞. Potassium bicarbonate.................. 3 drachms
Potassium citrate....................... 1 ounce
Tincture hyoscyamus.................... 3 fluidrachms
Syrup of Tolu...............q.s. to make 3 fluidounces.
Directions.—Teaspoonful every two hours.

46. ℞. Sodium phosphate...................... 2½ ounces
Sodium bromide........................ ½ ounce.
Directions.—Teaspoonful four times a day in water.

47. ℞. Mercuric chloride....................... q.s.
Petrolatum............................. 2 drachms.
One in ten thousand.

48. ℞. Salicylic acid........................... 2 drachms
Solution of ammonium acetate............ 2 fluidounces
Spirit of nitrous ether.................. ½ fluidounce.
Syrup................................. ½ fluidounce.
Directions.—Two teaspoonfuls every three hours until relieved.

49. ℞. Morphine sulphate...................... 3 grains
Potassium cyanide....................... 4 grains
Aromatic sulphuric acid................. 2½ drachms.
Syrup of wild cherry..............q.s. ad 4 fluidounces.
Direction.—Teaspoonful three times a day.

50. ℞. Creosotal............................. 1½ fluidrachms.
Basham's mixture....................... 4 fluidounces.
Directions.—Two teaspoonfuls after each meal.

51. ℞. Tincture of chloride of iron.............. 1 fluidounce
Diluted phosphoric acid................. 2 fluidounces
Glycerin............................... 2 fluidounces
100 per cent. solution of sodium phosphate
q.s................................ 8 fluidounces
Directions.—Teaspoonful in a half-glass of water after each meal.

52. ℞. Iron pyrophosphate..................... 2 drachms
Diluted phosphoric acid................. 3 fluidrachms
Syrup.........................q.s. ad 3 fluidounces.
Directions.—Teaspoonful in water an hour after meals.

53. ℞. Hyoscine hydrobromate.................. 2 grains.
Make 21 pills.
Directions.—One after each meal.

54. ℞.	Tincturæ krameriæ		℥ij
	Tincturæ opii		ʒiv
	Aquæ camphoræ		ʒiss
	Aquæ menthæ piperitæ		ʒj
55. ℞.	Calc. hypophosphitis		ʒiv
	Liquor potassii arsenitis		ʒj
	Tinctura ferri chloridi		ʒj
	Strychninæ sulphatis		gr. j
	Acidi phosphorici dil		ʒj
	Aquæ	ad	℥iv.
56. ℞.	Ferri et quininæ citratis		ʒiv
	Tincturæ valerianæ ammoniatæ		ʒvj
	Aquæ	q.s.	℥xij.
57. ℞.	Potassii bicarbonatis		℥j
	Potassii salicylatis		℥j
	Spiritus chloroformi		℥j
	Aquæ	q.s. ad	℥viij.
58. ℞.	Tincturæ opii		℥ss
	Liq. plumb. subacet. dil	q.s. ad	Oj.
59. ℞.	Hydrargyri chloridi corros		gr. ij
	Liq. calcis		℥xij.
60. ℞.	Quininæ sulphatis		gr. xxx
	Tincturæ ferri chloridi		ʒj
	Syrupi et aquæ	āā	℥j.
61. ℞.	Quininæ hydrochloratis		3.0
	Antipyrine		2.0
	Aquæ destillatæ		5.0
62. ℞.	Hydrarg. chlor. mitis		gr. xx
	Antipyrine		gr. xl.
	M. Ft. pulv. No. xx.		
63. ℞.	Liquor potassii arsenitis		
	Liquor strychniæ (B.P.)	āā	℥ss.
	Misce.		
64. ℞.	Potassium iodide		2 drachms
	Tincture of ferric chloride		3 fluidrachms
	Infusion of quassia, enough to make		6 fluidounces.
65. ℞.	Potassium chlorate		2 drachms
	Digalen (Cloetta).		
	Spirit of nitrous ether.		
	Compound tincture of cardamon of each		2 fluidrachms
	Water, enough to make		6 fluidounces.
66. ℞.	Syrup of chloral		1 fluidounce
	Heavy magnesia		1 drachm.
	Wine of ipecac		1 fluidrachm
	Tincture of belladonna		1 fluidrachm.
	Water, enough to make		6 fluidounces.
67. ℞.	Precipitated sulphur		1 drachm
	Prepared calamine		4 drachms
	Zinc oxide		4 drachms
	Glycerin		1 fluidounce
	Water, enough to make		4 fluidounces.
68. ℞.	Phenalgine		4 grains
	Acetyl salicylic acid		8 grains
	Exalgine		1 grain
	Caffeine		2 grains.
	Of such doses, 6, dispensed in papers.		
69. ℞.	Sodium cinnamate		0.10
	Stovaine		0.10
	Water		10.00.
	Make a solution.		

70. ℞.	Balsam of Peru	4 drachms
	Sulphur	1 ounce
	Salicylic acid	6 drachms
	White petrolatum	6 ounces.

Make an ointment.

71. ℞.	Natri. bicarb	ʒii
	Kali bicarb	ʒiv
	Magnes. sulph	ʒxii
	Aquæ	ʒvi.

72. ℞.	Syr. scillæ	ʒiv
	Syr. ipecac	ʒii
	Spt. æth. nit	ʒiii
	Spr. pruni virg	℥ii.

73. ℞.	Ext. belladonnæ	gr. i
	Pulv. camphor	℈i
	Acetanilidi	℈i
	Salolis	℈i
	Strych. sulph	gr. 1/10.

M. Fiant caps. No. x.

74. ℞.	Potass. chlorat.	
	Sodii. hyposulphit.	aa ʒi
	Ol. gaultheriæ	gtt. xii.

M. Fiant pulv. No. xii.

75. ℞.	Phenolphthalein	gr. xv
	Betanaphthol	ʒiss
	Salol	ʒii
	Menthol	gr. xx.

Mix and divide in 20 Konseals.

76. ℞.	Plumbi acet	gr. xxx
	Acid. acet. dil	ʒii
	Syr. tolutan	ʒiv
	Syr. limonis	℥iss
	Aq. cinnamon. ad	℥vi.

Misce.

77. ℞.	Atropinæ sulph	gr i
	Strychnin, hydrochlor	gr ii.
	Acid. salicylic	gr. iii
	Sodii biborat	gr. ii
	Aquæ destillat, ad	℥iss.

Misce.

78. ℞.	Potass. chlorat	gr. xx
	Calcii chloridi	ʒi
	Acid. sulphurosi	ʒii
	Aq. chlorof., ad	℥iii.

Misce.

79. ℞.	Ammonium carbonate	2 drachms
	Potassium iodide	1 drachm
	Spirit of ether	2 fluidrachms
	Chloroform water, enough to make	6 fluidounces.

80. ℞.	Tincture of ferric chloride	4 fluidrachms
	Hexamethylenamine	2 drachms
	Water enough to make	6 fluidounces.

Make a solution.

81. ℞.	Potassium iodide	2 drachms
	Diluted hydrobromic acid	4 fluidrachms
	Chloroform water enough to make	6 fluidounces.

Make a solution.

82. ℞.	Potassium iodide	3 drachms
	Potassium bromide	2 drachms
	Sodium sulphate	1 ounce
	Spirit of nitrous ether	4 fluidrachms
	Infusion of buchu. enough to make	6 fluidounces.

83. ℞.	Acid gallic		ʒi
	Ext. ergot. liq		ʒiss
	Acid. tannic		ʒij
	Tinct. ferri perch		ʒi
	Mag. sulph		ʒiij
	Aq.	ad	℥xij.

Sig.—℥i. 0.4 h.

84. ℞.	Potass. bromid		ʒiij
	Sod. salicyl		ʒiij
	Caff. citrat		grs. xl
	Aq. dest	ad	℥vj.

℥ss. 0.4 h.

85. ℞.	Acid. hydroch. dil		♏ xx
	Tinct. nuc. vom		♏ v
	Sp. æth. nit		♏ xx
	Sp. ammon. arom		♏ x
	Potass. iodid		grs. iij
	Aq.	ad	℥i.

(Mitte ℥xij.) t.d.s.

86. ℞.	Sol. iod. alcoholic. 2 per cent	℥i.

m.d.u.

87. ℞.	Ol. olivæ		℥ss
	Liq. vol. cc		℥iss
	Sp. rorismar		℥ss
	Aq.	ad	℥viij.

Ft. lotio.

88. ℞.	Tinct. iodi duplic	ʒiv
	Tinct. aconit. (Fleming's)	ʒiv.

M. Ft. applic. Dry the gum and paint on the application.

89. ℞.	Dec. symphyt. off	Oss.

Apply as fomentation to the heel as directed.

90. ℞.	Sodium bromide	4.0
	Magnesia	0.8
	Validol	4.0.

Divide into 12 capsules.

91. ℞.	Cacao butter	12.0
	Oil sweet almonds	15.0
	Sulphur precipitated	3.0
	Resorcin	1.5
	Oil rose	0.4.

92. ℞.	Balsam of Peru. Ointment of zinc oxide, of each	15.0.

Mix.

93. ℞.	Fluidextractum cubebæ	8.0
	Tincturæ hyoscyami	12.0
	Potassii citratis	24.0
	Aquæ destillatæ	60.0
	Glycerini	24.0.

M.D.S.

94. ℞.	Protargol	2.0
	Cocaine hydrochlorate	0.5
	Distilled water	60.0.

Sig.—External use.

95. ℞.	Pyramidon	0.3
	Antipyrine	0.2
	Salol	0.12
	Codeine	0.01
	Citrated caffeine	0.06.

M.F. Capsules D.T.D. No. 12.

Sig.—One every two hours as directed.

96. ℞.	Oil of mustard	40 drops
	Menthol	2 grammes
	Chloroform	20 grammes
	Solid petrolatum	40 grammes.

M.F. Unguentum.

Sig.—Rub in very briskly.

97. ℞.	Oleoresinæ aspidii	4.0
	Olei terebinthinæ	2.0
	Olei ricini	60.0.

Sig.—Use at one dose.

98. ℞.	Sodii salicylatis	4.0
	Sodii bicarbonatis	12.0
	Aquæ destillatæ	90.0

Misce.

99. ℞.	Pilula ichthyol	0.3.

Dentur tales doses No. xxiv.

100. ℞.	Terpinol	6.0
	Sodii. bens	6.0
	Heroin	0.1
	Ext. glycyrrhizæ pulv	4.0

M. Ft. capsulæ No. xxiv.

COMMENTS ON FOREGOING PRESCRIPTIONS

1. Liable to explode, as ammonia combines with iodine, forming the dangerously explosive nitrogen, iodide, NI_3.

2. The spirit of nitrous ether, if acid, is apt to act on the tannin of the uva ursi and froth violently, sometimes exploding the bottle.

3. Don't dispense. Dangerously explosive.

4. Can be put up if mixed cautiously in large open dish.

5. Mass these pills with kaolin and vaseline. Ordinary excipients will cause explosion.

6. This prescription was evidently written with the idea that the fat petrolatum would saponify with the calcium hydroxide as would an animal or vegetable fat. It does not do this, and an unsightly mixture results.

7. Chemical incompatibility. Insoluble quinine acetate formed.

8. Pharmaceutic incompatibility. Acacia precipitated by the alcohol. Remedy by reducing amount of alcohol by using a proportional quantity of fluidextract of cinchona and enough water to produce bulk equal to amount of tincture called for.

9. *Chemical.*—Red ferric hydroxide precipitated by ammonium carbonate.

10. *Pharmaceutical.*—Copaiba immiscible. Remedy by emulsifying.

11. *Chemical.*—Color changes from red to yellow.

12. *Chemical.*—When the salts are mixed in concentrated solution, the product is a dirty red color. When in dilute solution it is first colorless, afterward depositing a black powder.

13. This is all right, affording a good means of administering HCN, this being liberated in the action of citric acid on the potassium salt.

14. *Chemical.*—$2NH_4Cl + Ca(OH)_2 = CaCl_2 + 2NH_3 + 2H_2O$. Ammonia gas is generated.

15. *Chemical.*—Ammonia in spts. ammon. arom. acts on chloral to form chloroform, which is immiscible. Dispense with "shake" label.

16. *Pharmaceutical.*—The tincture and the collodion mix to a clear solution, but as soon as the ammonia water is added, the pyroxylin in the collodion is separated in a solid mass. Can be dispensed without altering properties by using spirit of ammonia instead of the water. It is apt to become lighter on standing, due to action of ammonia on iodine. Also a faint possibility of explosion, intimated by comparison with iodine prescription on p. 952.

17. *Chemical.*—This solution remains clear only when exactly neutral; the bismuth salt being insoluble in acid and the pepsin insoluble in alkaline solution. It being difficult to preserve neutrality, the bismuth citrate is always precipitated in time.

18. *Chemical.*—The calx saponifies the copaiba, just as does magnesia in the formerly official mass of copaiba; in this case, however, to make a creamy emulsion.

19. The first ingredient is from the British Pharmacopœia and is essentially our compound extract of colocynth. There is too much liquid and the mass will be too soft. Triturate in warm mortar until the tincture evaporates.

20. *Chemical.*—The two salts effervesce on mixing. Do not bottle until carbon dioxide is all evolved.

21. *Chemical.*—The salt in the bread may react with the silver nitrate to form insoluble silver chloride.

22. *Pharmaceutical.*—The soluble salt causes separation of camphor from the water. Accordingly, this must be dispensed with a "shake" label (see No. 26).

23. *Pharmaceutical.*—Fat in tincture of nux vomica precipitated by the hydroalcoholic tincture of cinchona, causing milkiness. If, however, the tincture of nux vomica be that of U.S.P. VIII., prepared from the extract, the difficulty will be obviated.

24. *Chemical.*—The carbonate reacts with ferrous iodide, forming insoluble ferrous carbonate, $K_2CO_3+FeI_2=2KI+FeCO_3$.

25. *Chemical.*—The free acetic acid in the Basham's mixture will precipitate insoluble quinine acetate.

26. *Pharmaceutical.*—The bromide, in dissolving, refrigerates the peppermint water, rendering the oil dissolved less soluble and causing excess to separate, making milky mixture. Remedied by dissolving the salt in pure water and adding peppermint water to the required amount.

27. *Chemical.*—The excess of bicarbonate will precipitate the quinine, the resin in the tincture of guaiac will be thrown out by the water. No remedy.

28. *Pharmaceutical.*—Resin of guaiac precipitated by the water. Remedy by emulsionizing.

29. By warming slightly, a plastic mass may be obtained.

30. *Pharmaceutical.*—Amount of acid not sufficient to dissolve the cinchonine, hence more is to be added.

31. *Pharmaceutical.*—The amount of alcohol necessary to dissolve the croton chloral will be enough to precipitate the acacia from the mucilage, so leave out the alcohol.

32. *Chemical.*—Precipitate when combined. Probably due to the action of tannin in the hamamelis on the hydrastis alkaloids.

33. *Chemical.*—Clear solution is formed by adding the tincture of iron and the solution of arsenous acid to about three ounces of freshly prepared Basham's mixture, dissolving the alkaloids in this mixture, adding an aqueous solution of the corrosive sublimate, and finishing with sufficient Basham's mixture to make four fluidounces. But the alkaloids are precipitated by the corrosive sublimate on standing, and the mixture is too dangerous to dispense.

34. Both *Chemical* and *Pharmaceutical.*—Tannin precipitates the morphine. Resin of myrrh separated by the syrup. Nothing can be done with it.

35. *Chemical.*—Almost anything is possible. Thus the bichloride separates mercury when combined with the potassium bicarbonate of Fowler's solution; it is incompatible with ferrous iodide and precipitate the alkaloids of the cinchona elixir, while the syrup is incompatible with everything else. As the *Pharmaceutical Era* (from which it is taken) says: "A much more incongruous mixture can hardly be devised."

36. Cocaine or any other alkaloid will be precipitated by the alkaline borax. If boric acid were used, no precipitation would occur.

37. The bichloride and the iodide combine to form potassio-mercuric iodide, an alkaloidal precipitant (p. 797). This will throw the cinchona alkaloid out of solution.

38. *Chemical.*—The iodide will precipitate some of the constituents of the paregoric and the syrup.

39. *Chemical.*—After standing twenty-four hours bottle containing this mixture exploded. Explosion due to decomposition of the nitrate by tannin and resinous matters in the fluid extracts; large quantities of nitrogen oxides being liberated. Do not dispense.

40. *Chemical.*—Incompatible, though often prescribed with good results. Silver salt reduced by vegetable extracts. Dispense by adding a grain of kaolin to each pill and making up with petrolatum. This will lessen likelihood of reduction, although not totally removing possibility.

41. *Chemical.*—The hyposulphite reacts with the precipitation of sulphur and the evolution of sulphurous acid gas. The sulphur precipitates in varying tints, from yellow, through pink, to gray, causing much annoyance in arousing suspicions of the patient. It is to be dispensed, however, as it possesses therapeutic value.

42. *Chemical.*—Precipitate of oxyiodides of arsenic formed.

43. *Chemical.*—The salts effervesce on combining, and a precipitation occurs when the tincture is added. The effervescence is probably due to the following reactions: $K_3C_6H_5O_7+KHCO_3+H_2O=K_2HC_6H_5O_7+CO_2+2KOH$. And the alkaline hydroxide precipitates the alkaloids from the tincture. A dangerous mixture that must be dispensed with a "shake" label.

44. This and the nine prescriptions that follow were published by W. F. Kaemmerer, who pointed out that the product is an unsightly mixture since magnesia is insoluble in water. He substituted magnesium sulphate thereby obtaining a clear fluid, but at the meeting where the prescription was submitted a majority of those discussing it, thought that such a change meant the taking of unjustifiable liberties with the doctor's orders.

45. Effervescence occurs, due not to acidity of the citrate, but to the acids (benzoic and cinnamic) of the syrup of Tolu.

46. Triturates to pasty mass, due to the 60 per cent. water in the official crystalline sodium phosphate. Best remedy is that of using exsiccated sodium phosphate, 1¼ ounces, and sugar of milk, 1¼ ounces.

47. Merely a problem in arithmetic, and the application of common sense in dispensing: Two drachms of a 1 : 10,000 ointment means $120 + \frac{1}{10{,}000} = \frac{120}{10{,}000} = \frac{12}{1000}$, or about 1/60 grain of bichloride. To weigh this small amount is practically impossible on the average prescription scale, and to secure the amount it is necessary to follow some procedure like that of Mr. Kaemmerer, who made an aqueous solution containing 1 grain of bichloride to 1000 minims, and mixing 12 minims of this solution with the petrolatum. If the use of water is objectionable make an ointment, containing 1 grain of bichloride and 99 grains of lanolin and then mix 1.2 grains of this with petrolatum.

48. The acid will be largely dissolved by the alkaline solution of ammonium acetate. There is a possibility that the salicylic acid may react on the spirit of nitrous ether, especially if it is acid. Kaemmerer filtered out excess of salicylic acid, a procedure not approved by most of those who discussed the prescription; one gentleman suggesting that enough ammonia water be added to insure complete solution.

49. This prescription is entirely safe, even though hydrocyanic acid is liberated by the sulphuric acid. It is merely fortifying the hydrocyanic acid content of the syrup.

50. Cresotal will not dissolve in aqueous liquids, so Mr. Kaemmerer emulsified with 1 drachm of acacia and 2 drachms of water and then added Basham's mixture. A good suggestion offered was to prepare two ounces of a double strength Basham's mixture, thus making possible a two-ounce emulsion of the creosotal.

51. If glycerin, solution of sodium phosphate, and a mixture of the acid and tincture of ferric chloride are mixed, a creamy mixture results. If glycerin, the acid, the tincture, and then the sodium phosphate solution are mixed and then warmed, a clear, light greenish solution results. In order to make a clear liquid, the solution of sodium phosphate (Liquor Sodii Phosphatis Compositus N.F.) must contain the pharmacopœial amount of citric acid.

52. If carelessly compounded, the ferric pyrophosphate will be precipitated by the acid. If the pyrophosphate is dissolved in 3 fluidrachms of hot water, the syrup then added, and lastly the acid, little by little, shaking after each addition, a clear solution results. Mr. Kaemmerer used Diluted Metaphosphoric Acid N.F. III., (p. 405) instead of the official diluted phosphoric acid.

53. As this stands, the prescription calls for an excessive dose of the alkaloid. As to compounding, use enough of a diluent (Mr. Kaemmerer used arrowroot) to make a pill weighing about 1 grain.

54. *Chemical.*—The tannin in the tincture of krameria will precipitate the morphine.

55. *Chemical.*—The arsenous acid of Fowler's solution produces, with tincture of ferric chloride, insoluble ferric arsenite.

56. *Chemical.*—The ammonia will precipitate the quinine from the scale salt solution.

57. *Pharmaceutical.*—Spirit of chloroform is immiscible with that quantity of water, and a milky mixture results on agitation, the chloroform separating on standing.

58. *Chemical.*—A popular lotion that must be dispensed with a "shake" label. Lead meconate precipitated.

59. *Chemical.*—The popular "yellow wash," a recipe for which is given in the National Formulary lime water reacting with mercuric chloride to form insoluble yellow mercuric oxide by the following reaction: $HgCl_2 + Ca(OH)_2 = HgO + CaCl_2 - H_2O$. Dispense with "shake" label.

60. *Chemical.*—The quinine will not entirely dissolve, there being an insufficient amount of acid in the tincture to accomplish the purpose. Add a few drops of hydrochloric acid.

61. *Pharmaceutical.*—The usually insoluble quinine salt will, under the influence of antipyrine, dissolve in the small quantity of water directed in the above prescription, forming what is called "chinopyrine," which affords a good method of administering quinine hypodermically.

62. *Chemical.*—Dangerous, as corrosive sublimate is formed by the following reaction: $3Hg_2Cl_2+H_2O+2C_{11}H_{12}N_2O=2Hg+Hg_2O+2HgCl_2+2C_{11}H_{12}N_2OHCl$.

63. This and the three prescriptions that follow are published by Donald McEwan, who states that the dispensing of Fowler's solution and solution of strychnine resulted in a fatality, even though the druggist labelled it "shake well." The patient did not shake the bottle and took as the last dose the sediment consisting of most of the strychnine precipitated by the alkali of the arsenical solution. The coroner decided that while neither prescriber nor dispenser were free from blame, no judicial action would be taken. In a similar case in South Africa, the prescriber was tried for manslaughter and acquitted.

64. Ferric chloride liberates iodine from the iodide.

65. The freshly dispensed prescription was a pink fluid, due to the chemical in the compound tincture of cardamon. After twenty minutes, the pink liquid changes to a muddy yellow mixture, which on standing, deposits a yellow brown precipitate leaving a colorless supernatant liquid. The precipitate contains crystals of potassium chlorate, which salt while freely soluble in the water prescribed, is precipitated by the alcohol in the spirit of nitrous ether. The yellowish part of the precipitate is due to the cinnamon of the compound tincture of cardamon. The bleaching action is due to hydrolysis of the ethyl nitrate in the spirit of nitrous ether, the first products being ethyl hydroxide (alcohol) and nitrous acid and the eventual dissociation of the latter into nitrogen dioxide and oxygen. The potassium chlorate hastened the bleaching action, which however, occurred when the chlorate was omitted. The dissociation of the ethyl nitrite is with formation of nitrous acid and this in turn decomposes the glucoside in the digalen. Inasmuch as the digalen and ethyl nitrate are decomposed and the potassium chlorate is precipitated, the mixture is physiologically inert and presents a difficulty for which no remedy can be suggested.

66. A troublesome combination because of formation of chloroform from the chloral by action of the alkaline magnesia, and because the alkali precipitates the alkaloids of ipecac and of belladonna; these dissolving in the separated chloroform.

67. This prescription is a modification of lotio calaminæ of the British Pharmaceutical Codex containing sulphur, which is not called for in the Codex recipe. All three solids should be dispensed as finely divided as possible.

68. The phenalgine and the acetylsalicylic acid when triturated turn pasty and George Eliot, who describes it, dispensed the phenalgine separately.

69. If the cinnamate is alkaline, the stovaine will be precipitated from the solution; hence the use of a chemically pure cinnamate is essential.

70. This and the five prescriptions which follow were published by H. A. B. Dunning. The ointment prepared by recipe, No. 70, when rubbed on the skin separates into greasy liquid and quill-like masses. If the balsam is mixed with an equal volume of alcohol and rubbed with an ointment made of the petrolatum and the other ingredients a satisfactory product is obtained.

71. Although solutions of bicarbonates and solutions of soluble magnesium salts are incompatible, the reaction takes place but slowly. The compounding of this prescription results in a perfect solution in which carbon dioxide is slowly but gradually liberated. After several hours the mixture becomes cloudy and finally a precipitate is formed. The more rapidly the carbon dioxide is allowed or caused to escape the sooner a precipitate forms; this is because the carbon dioxide serves to keep the otherwise insoluble magnesium carbonate in solution.

72. This mixture is persistently effervescent, due to separation of the ethyl nitrite from the spirit by action of the water of the syrups; the separate ethyl nitrite boiling at ordinary temperatures.

73. Camphor and salol liquefy in contact with each other and if the ingredients of this prescription are mixed as written, a paste results which requires a large quantity of absorbent powder to properly stiffen for dispensing in capsules. It cannot well be dispensed in soft elastic capsules. Dunning dispensed the prescription as follows: Pack the salol into ten No. 5 empty capsules. Mix the other ingredients and pack loosely into ten No. 1 empty capsules. Into the No. 1 capsules insert the No. 5 filled capsules so as to conceal the latter.

74. The potassium chlorate and sodium hyposulphite should be powdered separately and mixed lightly to avoid an explosion.

75. In dispensing this, powder the menthol and pack into thirty No. 5 capsules. Mix the other ingredients and place into the lower hălves of thirty konseals. Put a menthol capsule in each and proceed as usual.

76. This mixture, which with the two which follow were submitted by Peter Fenton, gives a white precipitate soon after making up. The precipitate is lead citrate. It may be assumed that the prescriber's intention here in adding syrup of lemon is merely for flavoring. By using simple syrup, to which some tincture of lemon has

been added, instead of syrup of lemon the formation of the insoluble lead salt is prevented.

77. In this case precipitation is prompt and the deposit abundant. The precipitate is due to the sodium borate throwing out the alkaloids. As written, no attempt should be made to dispense the above.

78. When compounded as written a copious precipitate is produced after standing about two hours or so. This is due to an interaction between the potassium chlorate and the sulphurous acid, as a result of which sulphuric acid is formed, which, in turn, then reacts with the calcium chloride to form calcium sulphate, thus:

$$\begin{aligned} KClO_3 + 3H_2SO_3 &= KCl + 3H_2SO_4 \\ CaCl_2 + H_2SO_4 &= CaSO_4 + 2HCl \end{aligned}$$

The incompatibility should be pointed out to the prescriber, but if this is impossible it should not be dispensed.

79. The compounded prescription became yellow and finally deposited a yellow sediment of iodoform; due to the fact that ether in the presence of air and water converts some of the latter into hydrogen dioxide and this oxidizing agent liberates iodine from the iodide.

80. In this, ammonium chloride is formed, formaldehyde is set free and ferric hydroxide is precipitated.

81. In compounding this prescription, Tait found that the liquid became yellow and then brown, due to liberation of irritating free iodine. Experiments showed that the addition of minute amounts of sodium hypophosphite even as little as ½ grain to a fluidounce of the mixture—prevented liberation of iodine. A lesser amount of the hypophosphite—say 1/16 grain to the fluidounce—prevented darkening of the mixture when kept protected from the light, but when exposed to sunlight the liquid turned brown. Curiously, if the mixture was then put in a dark place it bleached and the alternate darkening and bleaching, according as to whether it was in the sunshine or out, could be repeated again and again.

82. When this is compounded, there are deposited crystals of potassium sulphate which are less soluble in water than is sodium sulphate and in this mixture is still less soluble because of the presence of the alcohol in the spirit of nitrous ether.

83. This prescription and the seven which follow are taken from a series published in the *British and Colonial Druggists* and represent some of the usual types of prescriptions encountered in England. As to the one now under discussion the anonymous author states that it is reminiscent of the story of a well-known doctor-cricketer who, when acting as house physician was called to account by the hospital pharmacist for prescribing something in the "blue-black" line, and was rather curtly asked "if he desired his patient to take ink?" The doctor was not so ignorant as was supposed, for his reply was brief and to the point: "As ink is official in the British Pharmacopœia (mist. ferri aromat., B.P., '85), he failed to see the purport of the dispenser's query, and he certainly desired his patient to take ink."

84. Dispensed as written an unsightly and unsatisfactory mixture is produced. This is due to the unstable acidity of the caffeine salt. By substituting the equivalent quantity of caffeine alkaloid for the citrate prescribed, a clear mixture is presented, and, at the same time, the therapeutical intentions of the prescriber are maintained.

85. "Had not this prescription been written by one whose name was formerly on the register of chemists and druggists, there would have been no place for it in this category. Pharmacists look for good prescribing from quondam pharmacists, but, perhaps, at the prescribed moment a *lapsus mentis* occurred, or a desire to provide a worrier for his erstwhile calling crossed the mind of the prescriber."

86. This represents a weak alcoholic solution of iodine, free from potassium iodide, used in Scotland as an application to burns.

87. "Liquor volatilis cornu cervi and spiritus rorismarini indicate that this prescription was not originally written yesterday, although it was presented for dispensing quite recently. 'Liq. vol. cc.' stands for the true distilled spirits of hartshorn, which, it may be safely assumed, does not now exist; an old edition of Beasley states that a solution of carbonate of ammonia or (less properly) of caustic ammonia is usually substituted for it. The contributor of this selected one dispensed the less proper preparation 'liq. ammon. B.P.' What does the present Mr. Beasley say about this? Spiritus rorismarini indicates that the prescriber is or was an old Latin scholar, since he has genitived the first syllable of rosmarinus = ros marinus = roris marini = rorismarini."

88. "A double strength tincture of iodine is here prescribed, and, no doubt, with every reason. An authority quotes: 'Tincture of aconite (Fleming), combined with equal volumes of tincture of iodine (off.), is frequently ordered to be painted on the gums for pain.' This prescription, therefore, provides that variety which gives the 'salt' to pharmaceutical work, inasmuch as it also differs from the most

frequently demanded combination of all; in a mixture of equal parts of the tinctures of aconite and iodine.

89. "Recently prescribed by one of London's most famous surgeons. Further research into the mysteries of the fruits of the earth would be more in accordance with the natural employment of the Divine gift of reason to the use and benefit of mankind than is the present trend of some medical investigations and experiments. Martindale states that the formula given in the Extra Pharmacopœia for the preparation of a strong infusion of comfrey root approximates a decoction; this was acted upon in this instance."

90. According to Lascoff, who published this and the ten prescriptions which follow, to put this up in capsule form, the way it is written, is impossible, unless a mass is made, and then the capsules will be of an enormous size. But by adding 10 grains more of magnesia it will form a dry powder, and can be dispensed in No. 1 dry capsules.

91. The best way to dispense this prescription is to melt the cacao butter and the almond oil, then dissolve the resorcin in a few drops of water and rub it up thoroughly with the precipitated sulphur; then rub the rest of the ingredients on a slab, little by little with the melted cacao butter, until it forms a nice, smooth, perfect ointment.

92. This prescription looks very simple, but the prescriptionist will be surprised to find that when he rubs the two ingredients together, they form a gritty, hard ointment, which is absolutely impossible to apply to any sore. Lascoff found that a few grains of powdered acacia added to the balsam Peru and mixed with the zinc ointment, will form a smooth, soft ointment.

93. The resinous fluidextract is insoluble in the water, but if this and the tincture are emulsionized with acacia, glycerin and water, and are added to a concentrated aqueous solution of the citrate, a sightly, uniform mixture is obtained.

94. Protargol like most silver salts is precipitated by chloride, so the dispenser used the proportional quantity of cocaine nitrate and a clear solution resulted.

95. The ingredients of this prescription are triturated together and put into capsules, the combination eventually liquefied, but when salol, codeine and caffeine were triturated with a little sugar of milk (2 grains to each capsule), and then with the antipyrine and lastly with the pyramidon, the capsulated mixture was found stable.

96. This ointment was most satisfactorily prepared by melting the petrolatum in a corked wide-mouth bottle, dissolving the oil and menthol in the chloroform and mixing this solution with the melted petrolatum.

97. This mixture should never be dispensed, as Cushny and other authorities report that the filicic acid in the oleoresin dissolves in the castor oil and being absorbed. produces blindness.

98. This will become brown and eventually black, if made from ordinary chemicals. If strictly pharmacopœial salts are used, the blackening is retarded for five or six days. The discoloration is due partly to traces of iron in the bicarbonate and partly to decomposition of the salicylate by the alkali.

99. If, in preparing these pills, ordinary absorbent diluents are used very large pills are the result, says Dr. Lascoff. If, on the other hand, the ichthyol is evaporated on a water-bath, thus losing 45 per cent. of its original weight, small nicely rounded pills result. We are not prepared to state whether the evaporation of the ichthyol will cause any loss in its activity.

100. This mixture was found difficult to mass since the sodium benzoate refused to blend with the other ingredients. By emulsifying the terpinol with a little calcined magnesia and water and by adding the benzoate dissolved in a few drops of water, a uniform brown mass resulted.

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PART VII

LABORATORY EXERCISES

INTRODUCTION

Essential to the making of an allround pharmacist is the ability to carry out pharmaceutic operations, and any thorough course of pharmaceutic instruction must include laboratory exercises as well as theories. The following line of laboratory work has been used with success by the writer for the past two decades, and in order to secure best results, every step directed on the following pages should be followed by the student, *particularly the calculations, which are intentionally left incomplete*. To carry out these exercises, the student should have access to a laboratory, that is, a room provided with a working table, provided with gas, Bunsen burners (p. 69), water-bath (p. 74), filtering or retort stand with appropriate movable rings (p. 98), and a Liebig condenser (p. 96). Every drug-store should possess such a working table and appliances.

The special apparatus needed to carry out this work is as follows, and should be a part of the equipment of every well-conducted pharmacy:

1 thermometer: Centigrade markings on one side; Fahrenheit on the other, markings to 250°C.
1 pyknometer of about 25 mils capacity.
1 set of hydrometers; one, heavy Baumé degrees; the other, light Baumé degrees.
1 hydrometer cylinder.
1 alcoholometer.
1 set Lovi's beads.
1 Mohr-Westphal balance.
1 prescription balance.
1 less accurate scale.
1 package (100) 4-inch *white* filter-paper.
2 packages (200) 6-inch *white* filter-paper.
1 small rolling-pin.
1 lozenge cutter.
1 suppository mold (for 6 suppositories).
1 suppository compressing machine.
1 tin plaster dipper.
1 8-inch spatula.
1 4-oz. funnel.
1 2-oz. funnel.
1 4-oz. beaker.
1 2-oz. beaker.
2 1-pint Florence flasks.
1 4-oz. Erlenmeyer flask.
1 piece wire gauze for heating, 6 by 6 inches.
1 16-oz. porcelain evaporating dish.
2 2-oz. evaporating dishes.
1 glass rod, 3 feet long (to be cut into lengths).
1 length, about 3 feet, glass tubing.
1 8-oz. Wedgewood mortar.
1 1-pint glass percolator.
2 8-oz. wide-mouthed bottles.
1 pill tile, 6 by 6 inches.
1 60-mil graduate.
1 set of weights, 50 Gm. down.
24 test-tubes, 6 by ½ inches.

Of this list, the Baumé hydrometers, Lovi's beads, Mohr-Westphal balance, and suppository compressing machine, since expensive and not absolutely essential, can be omitted. The set from 8-inch spatula on can be purchased for about seven dollars.

The material needed for the experiments is:

2 oz. copper sulphate.
2 oz. alum.
½ lb. ferrous sulphate.
¼ lb. sodium sulphate.
1 oz. card teeth.
1 lb. sugar, granulated.
1 oz. benzoin.
1 oz. camphor.
1 oz. zinc oxide C.P.
1 lb. gentian, No. 30 powder.
1 qt. alcohol.
⅛ oz. acetanilide.
⅛ oz. compound extract of colocynth.
⅛ oz. calomel.
⅛ oz. resin of jalap.
⅛ oz. powdered gamboge.
⅛ oz. phosphorus.
1 oz. powdered althæa.
1 oz. powdered glycyrrhiza.
1 oz. powdered acacia.
¼ lb. chloroform.
2 oz. powdered potassium chlorate.
1 oz. confectioner's sugar.
1 oz. powdered tragacanth.
⅛ oz. soft extract of belladonna.
2 oz. butter of cacao.
½ oz. castor oil.
¼ lb. glycerin.
2 oz monohydrated sodium carbonate.
⅛ oz. stearic acid.
1 oz. spermaceti.
1 oz. white wax.
2 oz. oil of sweet almond.
1 oz. rose water.
1 oz. powdered borax.
½ oz. mercury.
1 oz. rose honey.
4 oz. cod-liver oil.
1 oz. rectified oil of turpentine.
1 oz. unslaked lime.
4 oz. ammonia water, 10 per cent.
1 lb. sulphuric acid C.P.
1 oz. potassium iodide.
1 oz. chlorinated lime.
½ oz. exsiccated sodium phosphate.
½ oz. tartaric acid.
2 oz. citric acid.
1 oz. sodium bicarbonate.
½ oz. mossy zinc.
¼ lb. hydrochloric acid.
¼ lb. nitric acid.
⅛ oz. precipitated zinc carbonate.
1 oz. honey.
¼ oz. iodine.
2 oz. lead acetate.
1 oz. litharge.
2 oz. olive oil.
1 oz. rosin.
1 oz. yellow wax.
½ oz. corrosive sublimate.
¼ lb. lard.
½ oz. bismuth subnitrate.
½ oz. white castile soap.

CHAPTER LIX

GALENIC PREPARATIONS

THERMOMETER TESTING

Boiling-point of Water.—Take two thermometers, one with Fahrenheit and the other with Centigrade scale. Suspend each in pint flask, which should rest on wire gauze or ring, high enough to permit a flame of Bunsen burner underneath. Have in the flask about 150 mils water, and do not let the thermometers dip below the surface of the water.

Apply heat, and when water boils and a goodly amount of steam is passing from the flask, read the height of mercury in each thermometer. The Fahrenheit will read about 210°; the Centigrade, about 98°. If much below these points, it is likely due to part of the thermometer being outside the flask and beyond influence of steam zone. To insure full action of steam, the neck of the flask may be lengthened by means of a roll of stiff paper or by inverting over flask a narrow glass percolator. The latter method is, however, not highly satisfactory, first because of danger of cracking percolator; second, because the condensed steam drops on outside of flask.

Note.—Water boils at 212°F. or 100°C. at *sea-level,* or at the atmospheric pressure equal to 760 millimeters of mercury. (See p. 87.) If the thermometer is tested in a high building or at any place higher than sea-level, the boiling-point will be less than the standard.

There is no mathematic formula expressing relation of boiling-point to atmospheric pressure which can be considered a true law, but Regnault worked out a table of boiling-points under different pressures which can here be condensed to the following four lines:

Barometric pressure.	*Boiling-point of water.*
91.92 mm.	50°C.
525.45 mm.	90°C.
760.00 mm.	100°C.
1520.00 mm.	120.4°C.

To this can be added the statement that an ascent of 1080 feet makes a decrease in the boiling-point of water of 1°C.

Melting-point of Ice.—Put four-ounce funnel into iron ring attached to filtering stand and place two-ounce beaker beneath it. Break ice into pieces about size of a pea, and fill funnel with same. Insert in midst of ice the two thermometers used in boiling-point experiment, and let stand five or ten minutes; then take out and read quickly. The Fahrenheit thermometer should read 32 degrees—the Centigrade, zero degrees.

SPECIFIC GRAVITY OF LIQUIDS

First, estimate specific gravity as follows:

Take a one-ounce graduate and carefully tare it. "Tare" means to counterbalance it—to put on the other scale just enough weights so that it will be exactly balanced.

Now, very carefully measure into it exactly one fluidounce of water (distilled, if possible) and note how many grains the water weighs.

Then weigh in similar manner one fluidounce of alcohol. Estimate its specific gravity by comparison of its weight with the weight of the fluidounce of water, and then looking in the back of the pharmacopœia or dispensatory, find the table showing alcoholic strength according to specific gravity (commonly called alcohol table), and deduce from the specific gravity what the strength of the alcohol is.

Lastly, find the weight of a fluidounce of glycerin and work out its specific gravity from this weight, remembering always that specific gravity is the relative weight of a body as compared to the weight of an equal bulk of water.

Then do same work more accurately by means of pyknometer. (See p. 48.) The necessary data to be obtained are as follows:

Water.—Weight of pyknometer ——————
Weight of pyknometer filled with water ——————
A. Weight of *water* held by pyknometer ——————
Alcohol.—Weight of pyknometer ——————
Weight of pyknometer filled with alcohol ——————
B. Weight of *alcohol* held by pyknometer ——————
Glycerin.—Weight of pyknometer ——————
Weight of pyknometer filled with glycerin ——————
C. Weight of *glycerin* held by pyknometer ——————

Calculations.—Since the same pyknometer is used in each case, and since specific gravity means how many times heavier than water is a certain substance, we find the specific gravity of alcohol by dividing weight of alcohol by weight of same volume water:

B ÷ A = sp. gr. of alcohol;
—— ÷ —— = ——————

and we find the specific gravity of glycerin by dividing its weight by weight of same volume of water.

$$\text{C} \div \text{A} = \text{sp. gr. of glycerin.}$$

____ ÷ ____ = ________

Oil of Turpentine.—Lastly, fill pyknometer with oil of turpentine, and from the weight of turpentine deduce the specific gravity of that liquid, viz.:

Weight of pyknometer filled with turpentine	÷	by weight of pyknometer filled with water	=	specific gravity. (How many times the oil of turpentine is heavier than water.)
	÷		=	

Be sure to wash the pyknometer carefully after the turpentine experiment until free from the odor of that oil.

Remarks.—In weighing, give value to centigrammes.

Use *distilled* water in all specific gravity experiments. In weighing the empty pyknometer, be sure it is absolutely dry (wipe it with clean handkerchief) both inside and out.

In filling it with any liquid be sure to have no air-bubbles in the liquid and to have it completely filled up to top of capillary orifice in stopper. The latter is accomplished by filling almost to top of neck of pyknometer, and then suddenly and evenly plunging the stopper into the neck. The excess of liquid passes through capillary to top of stopper, and is carefully wiped off with a piece of filter-paper. The entire pyknometer is then carefully wiped with a clean handkerchief and then weighed.

In wiping the pyknometer after wiping tops of stopper the heat of hand may cause expansion of liquid, which will rise through capillary to top of stopper. Do not wipe off this excess, but weigh it on top of stopper.

After weighing, empty out liquid and carefully wash out pyknometer with water (and alcohol if necessary), and dry perfectly before filling with another liquid. Water, if present, will contaminate the other liquid.

In accurate work the temperature at which pyknometer is filled should be noted, and, if possible, the liquid should be at 25°C.

SPECIFIC GRAVITY OF LIQUIDS WITH HYDROMETER

Take three tall cylinders and fill about three-quarters—the first with water, the second with alcohol, the third with glycerin.

Take two hydrometers (p. 49), one for heavy liquids, the other for light liquids, and note to which degree the hydrometer sinks in each liquid—the line just appearing at the surface of liquid.

	Degrees light.	*Degrees heavy.*
Water		
Alcohol		
Glycerin		

These are "degrees Baumé," and calculate therefrom by process given on p. 50 the specific gravity of each liquid. From the specific gravity of the alcohol deduce by means of alcohol table given in the pharmacopœia its alcoholic percentage.

Remarks.—Be sure that each cylinder is perfectly clean and dry before pouring liquids in, so that each liquid can be returned to container after the estimations, absolutely pure. In the same way carefully clean and dry each hydrometer before transferring to another liquid.

Avoid air-bubbles in putting hydrometers into liquids, as air is lighter than the liquids and air-bubbles vitiate results.

As the principle of the action of the hydrometer is fully explained on p. 49, nothing but the actual operation is here given.

With Alcoholometer.—Take very tall cylinder—a long narrow percolator with cork in neck does quite nicely at a pinch—and fill about nine-tenths with alcohol. Sink therein the alcoholometer (p. 51) and note point at which it floats. Note the two scales on the alcoholometer—one the alcoholic percentage, the other, its value in "proof." For "proof" valuation see p. 592.

With Lovi's Beads.—Throw a handful of Lovi's beads into water in a pint graduate. Some will sink, some will float on surface, and perhaps one will float midway in liquid. Take out those on the surface and all will be found to have specific gravity less than water; those which have sunk have specific gravity greater than water, while the one floating will be the specific gravity of water. Carefully dry and repeat with any other liquid if desired.

With Mohr's Balance.—Take Mohr's balance (p. 52), and note that the sinker in air is exactly counterpoised by weight on other end. Put water into cylinder, and immerse sinker therein. Note that the buoyant force of the water presses sinker upward. Place largest weight on notch directly over place from which sinker is suspended, when equilibrium will be restored. If desired, the *volume* of the sinker can be measured by sinking it into water contained in a burette and noting rise of water; the *weight* of weight which restores equilibrium may then be taken, in which event it will be found that the *volume* of the sinker, expressed in cubic centimeters, is just the same as number of grammes be that the weight weighs.

(The portion of the work just given is optional.)

Having gotten the balance into equilibrium by placing weight in notch over point of suspension, take sinker out of water, dry, and immerse in alcohol. It will then be found that the weight and sinker are heavier than the buoyant force of the alcohol. Move weight to next notch toward middle of beam (nine-tenths the distance between central knife-edge and point of suspension of sinker). It will still be too heavy. Move to next notch (eight-tenths the total distance). That will be a trifle too light, showing that the alcohol is something over eight-tenths as heavy as water (over sp. gr. 0.800). Use the two smaller weights—one one-tenth as heavy as the first, the other one-tenth as heavy as the second. The number of notch on which the second will all but produce equilibrium will give the second decimal point of the specific gravity (thus, if it all but balances on notch No. 2, the specific gravity will be 0.820). Then, with the third weight, bring balance to perfect equilibrium, and use this notch number as the third decimal point place.

Immerse dried sinker into *glycerin*, and weigh as before. It will be found that this liquid will buoy up the beam even when the heaviest weight is placed in the notch directly over the point of suspension of the sinker; that the buoyant force of glycerin is greater than that of water. Therefore, leaving the heaviest weight on the notch over point of suspension of sinker, where it represents the specific gravity 1.000, take the mate to the heaviest weight and place it on the notch where it most nearly balances the beam—if, when on notch three, it is too heavy, then put it on notch two, and if this is a trifle too light, consider the specific gravity as 1.20, and fill out the second and third weights on the appropriate notches as in the alcohol experiment. In this way deduce the specific gravity of glycerin.

Specific Gravity of Solids.—As learned on p. 53, the two important methods of taking the specific gravity of solids are, first, comparing the weight of a solid to the weight of an equal volume of water, and, second, by dividing weight in air by loss of weight of the solid in water. In the latter case we divide by *loss of weight in water* because, according to the Archimedes theorum (p. 54), loss of weight in water equals the weight of water displaced when the body is immersed in water; also equals the weight of a bulk of water equal to bulk of body immersed.

The first part of the following work is given in the hope of proving the Archimedes theorum to the student:

1. Take 20 Gm. brass weight and weigh in air with other weights to prove it is 20 Gm.

Then take test-tube and half fill it with water, marking water-level by a scratch with a file or with a piece of string or rubber band. Then sink therein the 20 Gm. brass weight, to which a silk thread is attached. The water will rise, the amount displaced being, of course, exactly equal to the bulk (the volume) of the weight. Mark point to which water water rises as the original level of water was marked. Then remove weight carefully, bring water in test-tube to original level if any is lost in removing weight, and pour in water from graduate to highest mark, and thus measure in mils the amount of water displaced.

Since 1 mil distilled water weighs 1 Gm. we can put down—

20 Gm. brass weight displaces —— mils water.
has same volume as —— mils water.
has same volume as —— Gm. water.

Since specific gravity is telling how many times heavier a substance is than the same bulk of water, we can deduce the specific gravity of the brass thus:

Weight of brass		Weight of same volume of water		Sp. gr. of brass.
(20 Gm.)	÷		=	

Now, take same brass weight, hang to the hook from which the scale of the balance is suspended, immerse in water contained in a beaker held independent of the hanging scale pan, and weigh immersed in water.

As in the experiment with the Mohr's balance, it will be seen that the brass weighs less in water than in air, due to the buoyant force of the water. Weight in air minus weight in water equals *loss of weight in water*.

If the operation is conducted with care, it will be found that the *loss of weight of brass in water is exactly the same as the weight of the water displaced* in the previous experiment, thus proving the Archimedes theorem. Lastly, the loss of weight in water equals the weight of an equal bulk of water, hence, when more convenient, instead of finding the weight of an equal bulk of water by the test-tube experiment, we can weigh the substance in water and deduce specific gravity as follows:

Weight brass in air ÷ Loss weight brass in water = Sp. gr. of brass.

Specific Gravity of Wax.—To estimate the specific gravity of a body by "loss of weight in water," the substance must be completely immersed. Wax and many other substances float on water, and to get the specific gravity of such a body, it has to be forced beneath the surface of water by means of an appropriate weight, say the 20 Gm. weight of the preceding experiment. The loss in weight of such a sinker under water then enters into the calculation, rendering it somewhat more difficult, as the following data must be taken:

Weight of wax in air........................ —— Gm.
Weight of 20 Gm. brass weight in air............ —— Gm.

Weight of both together in air.................. —— Gm.
Weight of both together in water............... —— Gm.

Loss of weight of both together in water......... —— Gm.
Loss of weight of brass alone in water........... —— Gm.
Loss of weight of wax alone in water............. —— Gm.

Then apply rule:

Weight of wax in air ÷ Loss of weight of wax in water = Sp. gr. of wax.

Remarks.—In performing this experiment, the wax must be firmly attached to the silk thread by which the brass weight is suspended, and both immersed well under water, as in the foregoing experiment. In all cases of this kind great care must be exercised in removing all air-bubbles from the immersed solids, as such bubbles render the solids more buoyant, and hence vitiate the results.

When wax data are worked out, there will be noticed what seems at first an astonishing fact—*that the wax loses more weight in water than it actually possessed in air.* This can, however, be understood if we remember that weight is a purely relative state; that it represents the downward force of the earth's gravitation exerted on a solid with naught but the air to interpose. On the other hand, when immersed in water, the buoyant force of that liquid—the repelling force of its molecules—pushes the solids *up* the same time that gravitation is drawing it *down*.

In the case of solids lighter than water, the upward force of the water is greater than the downward force of the earth; hence the "loss of weight in water" is greater than "the weight in air."

Specific Gravity of Alum.—Many solids dissolve in water, and these cannot be weighed in water, hence in such cases the specific gravity of such solids must be determined by weighing the solid in some liquid in which it will not dissolve. In this case we employ the oil of turpentine, the specific gravity of which has just been taken with the pyknometer.

The alum suspended by silk thread is weighed in air, then is immersed in a beaker containing oil of turpentine, and weighed, when we get the following data:

Weight of alum in air —— Gm.
Weight of alum in turpentine —— Gm.
Loss of weight of alum in turpentine —— Gm.

If we divide the weight of the alum in air by its loss of weight in turpentine, we find how many times heavier it is than oil of turpentine. This we do not care to know; what we want to know is, how many times heavier it is than water; hence we must indirectly estimate what the loss of weight of the alum would be in water. This we can figure out by the following proportion:

$$\begin{array}{ccccccc} \left\{\begin{matrix}\text{as the sp. gr.}\\ \text{of turpentine}\end{matrix}\right\} & \text{is} & \left\{\begin{matrix}\text{to the sp. gr.}\\ \text{of water}\end{matrix}\right\} & \text{so} & \left\{\begin{matrix}\text{the loss of weight}\\ \text{in turpentine}\end{matrix}\right\} & \text{is} & \left\{\begin{matrix}\text{to the loss of}\\ \text{weight is water}\end{matrix}\right\} \\ \underline{\qquad\qquad} & : & 1.000 & :: & \underline{\qquad\qquad} & : & x \\ a & & b & & c & & \end{array}$$

$$x = \frac{b \times c}{a}$$

Having thus deduced loss of weight of alum in water, we estimate its specific gravity by the regular rule:
Weight in air of alum ÷ Loss of weight in water = Sp. gr. of alum.

PHARMACEUTIC MANUFACTURING

MAKE GRANULATED COPPER SULPHATE

Copper sulphate	25 Gm.
Water	35 mils

Put copper sulphate into pint flask, add the water, and dissolve by aid of heat, putting flask over Bunsen burner on wire gauze. When dissolved, filter through plaited filter into pint evaporating dish. Put dish on wire gauze, and evaporate with constant stirring until pellicle forms on surface. Then take from heat and stir constantly until cold. Throw mass on plain filter, and when mother liquor has drained off, open filter and dry granules between sheets of paper.

Notes.—Folding plaited paper see p. 133.

Pellicle.—The "scum" of crystals forming on surface of the evaporating liquid.

Plain Filter.—See p. 133.

Wet both filters with water before using.

Avoid formation of white powder (the exsiccated salt) on edges of the liquid.

The *mother liquor*, after filtration, can be thrown away. (See p. 148.) Avoid use of iron spatula in all this work with chemicals. Use glass rod whenever possible.

MAKE GRANULATED ALUM

Alum	25 Gm.
Water	25 mils

Dissolve the alum in the water in pint flask, as directed in granulated copper sulphate, filter into pint evaporating dish, and evaporate on wire gauze with constant stirring until pellicle forms. Collect granules on plain filter—in short, treat exactly as granulated copper sulphate.

Remarks.—The only additional precaution is to avoid evaporating too far, as a sticky mass (partially exsiccated alum) will result.

MAKE GRANULATED POTASSIUM CHLORATE

Dissolve 25 Gm. potassium chlorate in 65 mils water in pint flask, filter through plaited filter into pint evaporating dish, and evaporate on *water-bath* until pellicle forms. Stir until cold, and collect granules on plain filter as in granulated copper sulphate.

Remarks.—*Water-bath.*—See p. 74.

Used because the chlorate must not be heated intensely, lest it decomposes—$KClO_3 = KCl + 3O$.

Note the different solubility of these three salts in hot water

MAKE GRANULATED FERROUS SULPHATE

Copperas	25 Gm.
Water	25 mils
Diluted sulphuric acid	1.25 mils (about 20 drops)
Card teeth	sufficient quantity
Alcohol	6 mils

Place the ferrous sulphate in pint flask, add the water mixed with the acid, and lastly add a pinch of card teeth; warm gently on wire gauze over Bunsen burner until dissolved and the solution is a green color. Then filter through plaited filter into tared evaporating dish, and evaporate on sand-bath until the liquid weighs 38 Gm. Then stir constantly until cool and throw mass on to funnel stopped with plug of absorbent cotton.

When the granules are completely drained of the mother liquor, pour the alcohol on the granules, and when this is drained, throw granules on filter-paper and dry quickly without aid of heat.

Remarks.—This is practically the official process for making Ferri Sulphas Granulatus, U.S.P. (See p. 508.)

Card teeth are pieces of bright iron wire, and a "pinch" means 2 to 5 Gm. When these are added to the solution in the presence of the acid, hydrogen is produced (note evolution), and this reduces any ferric sulphate present in the copperas to ferrous sulphate. This change is easily noted in the conversion of the brownish liquid to a pure green tint.

Tared dish means that the evaporating dish must first be weighed, and it is well to mark with lead-pencil its weight on the outside of the dish. The liquid is then evaporated until dish and contents weigh the weight of the dish plus 38 Gm.

Sand-bath.—Any flat dish containing sand will do. (See p. 73.)

Collection of Granules.—Observe, instead of using a plain filter, the granules are collected on a plug of cotton in neck of funnel. This is to get the water off as quickly as possible, since green ferrous sulphate is very easily converted (at least partially) into red-brown ferric sulphate, especially when water is present.

Washing with alcohol is done to remove last traces of water, and the granules, when thrown on filter-paper, are wet with alcohol and not with water. Alcohol being more volatile, the granules dry more quickly.

Dry at Low Heat.—No artificial heat must be used, else the green granules will change to a white powder—to the effloresced salt. So soon as dry, the granules should be bottled.

Granular salts are preferable to crystals in prescription work, because more easy to weigh and to dissolve. They usually save the necessity of powdering in a mortar.

MAKE CRYSTALLINE SODIUM SULPHATE

Dissolve 50 Gm. sodium sulphate in 20 mils warm water (not boiling) in pint flask, and filter into beaker glass. Let stand, and note sudden formation of crystals with evolution of some heat. Let stand until next day, and then collect crystals on plain filter and dry. The mother liquor which drains off may be evaporated some and may yield another batch of crystals, though not so fine nor so pure as the first.

Remarks.—The sudden formation of crystals occurs only when conditions are just right. (See p. 443.)

Filtration.—In all cases where filtration is for the purpose of clearing a liquid, a plaited filter is used. In case the solid part—be it in the form of granules, crystals, or precipitates—are wanted, plain filters are employed. (See p. 133.) Whenever aqueous liquids are to be filtered, the filter-paper should be first wet with water.

MAKE CRYSTALLINE FERROUS SULPHATE

Put 25 Gm. copperas in pint flask, and add thereto 25 mils water and 5 mils diluted sulphuric acid and a pinch of card teeth, and dissolve with gentle heat. Filter into beaker, and put in a pinch of card teeth and let stand until good "crop" of crystals are obtained. (Say, one to three days.) Collect these on plain filter and dry.

Remarks.—This process resembles making granulated ferrous sulphate, for remember that granules are merely minute crystals. (See p. 151.)

Card teeth are added to filtered liquid to keep the crystallizing ferrous sulphate from being oxidized to ferric sulphate. They should be carefully removed from the finished crystals.

The *mother liquor* may be concentrated; when more, but poorer, crystals are obtained.

MAKE ROCK CANDY

Dissolve 25 Gm. sugar in 10 mils water by means of gentle heat in Erlenmeyer flask; transfer, without filtering, into test-tube, stick a glass rod or piece of twine therein, and let stand several days. The sugar will crystallize on sides of tube and on rod in large crystals.

Remarks.—The sugar solution (syrup) is too thick to filter. Rock candy is made commercially by pouring such a thick syrup into wooden vats containing frames strung with cord, and the sugar in crystallizing deposits on the cords, making the rock candy in strings. The cord acts as a nucleus. (See p. 148.)

MAKE EXSICCATED ALUM

Recipe.—**Alum, in small pieces**	**20 Gm.**
To make..	**11 Gm.**

Place the alum in a tared shallow porcelain dish so as to form a thin layer, and heat it on a sand-bath until it liquefies. Then continue the application of a moderate heat, with constant stirring, until aqueous vapor ceases to be disengaged, and a dry, white, porous mass weighing 11 Gm. is obtained. When cold, reduce the product to a fine powder, and preserve it in well-stoppered bottles.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Remarks.—Exsiccation is driving off water of crystallization from a crystal, and is here directed to be performed to show the student that a dry crystal does contain water, and that in large amounts.

On heating, the crystal liquefies by dissolving in the crystal water, and on further heating the water can be seen to vaporize, and if wanted, the steam can be condensed on some cold surface. The loss of water is is shown in the fact that 20 Gm. of crystal alum yields only 11 Gm. dried alum, representing a loss of 9 Gm. of water, or 45 per cent—$\frac{9}{20} \times 100 = 45$ per cent.

What is the actual percentage of water in $K_2Al_2(SO_4)_4+24H_2O$. Estimation by molecular weight (p. 363).

The dish must be tared and the mass heated until it weighs 11 Gm. plus weight of dish. Be sure to wipe all sand off dish before weighing, and also scrape all adhering alum from stirring rod and put into dish.

Stirring the tough mass is a matter of some difficulty. Best accomplished by holdng a glass rod firmly down across top of dish and stirring with a smaller rod.

MAKE EXSICCATED FERROUS SULPHATE

Recipe.—**Ferrous sulphate,** in coarse powder .... **20 Gm.**

Allow the salt to effloresce at a temperature of about 40°C., in dry air, and then heat it in a porcelain dish, on a water-bath, constantly stirring, until the product weighs about 13 Gm. Lastly, reduce the residue to a fine powder, and transfer it at once to perfectly dry, well-stoppered bottles.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Remarks.—*Effloresce,* losing water of crystallization at low temperatures (p. 151). Effloresce and finally exsiccate at low temperature, to avoid possible oxidation.

Note change from green crystals to a gray-white powder.

Note loss in weight from 20 Gm. to 13 Gm., a loss of 7 Gm. water, or 35 per cent. ($\frac{7}{20} \times 100 = 35$).

This is not all the water in the crystals. Estimate by molecular weight percentage in $FeSO_4 + 7H_2O$.

SUBLIME BENZOIC ACID

Take benzoin (say, 5 to 10 Gm.), rub with about twice the quantity of sand, and put in tin ointment box. Cover with paper cornucopeia, and heat on sand-bath not exceeding 120°C. for an hour. Then open paper and note small shining crystals (Fig. 149).

Remarks.—*Sublimation.* (See p. 106.)

For condensing the vapor of solids, cool air is usually sufficient. Avoid high heat, as it causes decomposition, with formation of very irritating vapors.

SUBLIME CAMPHOR

Take lump of camphor (5 to 10 Gm.) and put in small evaporating dish. Cover same with small inverted funnel, which should fit inside the dish, and place over neck of same the beaker. Place on water-bath and heat. The camphor sublimes, and its vapors condense in funnel and beaker in handsome crystals (Fig. 107).

POWDER FOLDING AND WRAPPING

Camphor	5 Gm.	(powder with a few drops of alcohol).
Zinc oxide	5 Gm.	

Triturate together in mortar, divide by eye into 12 papers, fold, put into box, and wrap box, making neat package.

Remarks.—*Powdering camphor* is an example of pulverization by intervention (p. 118).

Folding of Powder Papers.—Crease all papers, lay down evenly, and proceed as on p. 285.

Wrap box in paper neatly, as explained on p. 286.

The division of the powders can be gotten accurately only by weighing each separately. In this case each powder should weigh—

$$\frac{5+5}{12} = \text{Gm., or } 0.83 \text{ Gm.}$$

The process is not difficult after one becomes expert at it. In this case divide by eye (see p. 285), and then prove the uncertainty of this plan by weighing three finished powders taken at random.

DRUG GRINDING

Reduce gentian root by means of mill or iron mortar to a No. 30 powder, using a No. 30 sieve in the work. Take 50 Gm. of the powder and make into a neat package. (See p. 289.)

MAKE FLUIDEXTRACT OF GENTIAN

Gentian	50 Gm.
Diluted alcohol, U.S.P.	q.s.

Put drug into pint evaporating dish, and moisten with 50 mils dilute alcohol; put into 8-ounce wide-mouthed bottle, cork, and let stand forty-eight hours. Then percolate.

PERCOLATION

Take percolator, put cork and percolating tubing (p. 164) into neck, and pour water in to see if it leaks. If it does not leak, pour out water, remove the cork and tubing and wipe percolator dry; insert plug of cotton in neck of percolator and a layer of cotton on that. Then pour in the moist gentian and pack firmly with gentle and uniform pressure. Then cut a piece of filter-paper so as to fit inside the percolator, and place this on top of the packed drug, laying a piece of glass—glass stopper—on top to hold the paper down. Then fit the rubber tubing and cork to percolator again, place percolator on ring (p. 160) pour on the drug 100 to 150 mils diluted alcohol, and cover top of percolator in some way to prevent evaporation. Place percolator tubing into 8-ounce wide-mouthed bottle, which has been previously graduated to 40 mils. Let percolation proceed at the rate of 2 to 5 drops a minute, regulating the flow by raising the receiver if it runs too rapidly, or lowering same if it runs too slowly. When 40 mils of percolate have dropped through, let the percolate drop into pint flask and cork the wide-mouthed bottle containing first percolate, labeling it "reserved portion." Continue percolating into pint flask until the drug is exhausted (perhaps more than a pint of percolate will be necessary), and when this accomplished, cork the pint flask and label "weak percolate." It is needless to say that as the first menstruum (the diluted alcohol) passes through the drug, more menstruum is poured on, care being taken always to have some menstruum covering the drug. When the drug is exhausted, the weak percolate is to be distilled.

Remarks.—*Percolation.*—For full description, see p. 161.

Testing Percolator Fittings.—This is essential, for if the tube leaks the percolation will prove a messy business.

Plug with Cotton.—This can best be done with a long glass rod or tube, though a piece of wire answers. The percolator must be perfectly dry.

Handling the Drug.—*Grind to only No.* 30 *powder*, because the cells of gentian are large, and most of them are ruptured when in No. 30 powder. (See p. 117.)

Moistened before packing, so as to permit the drug-cells to swell. If put in percolator dry and menstruum then poured on, the drug swells so much that percolation is impeded. (See p. 161.)

Pack Drug Evenly.—If one side is packed more loosely than the other, the menstruum will run down the looser side, and that tightly packed will not be exhausted. Uneven packing is shown in the descent of the first menstruum through the drug. Should pass down in a perfect ring. (See p. 162.)

Percolation.—*Do not pack too tightly,* else the percolate will drop too slowly. Sometimes, under these circumstances, the percolate refuses to drop, and the only thing to do is to empty out drug and pack again. Sometimes the percolate can be "coaxed" into dropping by applying suction at end of tube, or by filling percolator with menstruum. If the first 40 mils heavy percolate can be gotten through, the lighter weak percolate will usually run without trouble.

Filter-paper on top, to keep upper layer of powder from floating to top of menstruum. Glass weight holds the filter-paper down.

Reserve First 40 *Mils.*—If properly percolated the first 40 mils is supposed to contain the soluble principles of about 40 Gm. of drug.

Percolate to Exhaustion.—The strength of the remaining 10 Gm. of drug is hard to remove, requiring about ten times the amount of menstruum as does the reserved portion. Percolate until the drops of liquid are only a faint straw color and almost devoid of bitterness.

Menstruum.—The solvent used in exhausting drug. In this case the menstruum is diluted alcohol, U.S.P.—equal volumes of alcohol and water.

Keep Drug Covered with Menstruum.—If not, the menstruum in the upper layers evaporates, leaving fissures, and when fresh menstruum is poured on, it will run through the fissures rather than through the drug.

Distillation of Weak Percolate.—Fit pint flask about half filled with weak percolate with a cork, bore hole through cork with rat-tail file or with cork-cutter, and in this hole snugly fit a piece of glass tubing bent to an angle of 60 degrees; pass the other end of this tube through hole in a cork, fitting into neck of Liebig condenser.

Immerse flask in water-bath, preventing direct contact with bottom by having rest on wad of paper. Connect flask and condenser, fastening latter in place with appropriate clamps, and pass a stream of water through condenser, entering from the lower end and emerging from top. Get water either from water main or by syphoning from pan of water placed on shelf.

Start heat under water-bath and continue lively heat, replenishing water in bath when necessary. Collect distillate in second pint flask, and continue distillation until over half of the weak percolate has distilled over. Then pour residue in pint evaporating dish, and evaporate on water-bath with constant stirring until residue is of the consistency of soft extract.

Remarks.—Rig up distilling apparatus as on p. 95.

For glass bending and cork boring, see p. 97.

Condensing water run in lower end of condenser—not the upper end, as the heated water rises and must be removed from highest level.

Only about three-fourths of the percolate is distilled, since percolate is only half alcohol, and that is what we wish to save. Since the water is of no value, we evaporate it in open air, as it will evaporate more quickly that way than by distillation.

The *alcoholic strength of the distillate* can be estimated by taking its specific gravity and referring to alcohol table in the pharmacopœia.

Do not have the distilling flask full of percolate, as it will distil too slowly or froth over into condenser. If you have a pint of percolate or over, add same to distilling flask in portions, pouring in new portions as that part already in flask has evaporated.

Evaporate Residue with Constant Stirring.—Remember that the residue is now aqueous, and that you cannot *boil* water on a water-bath. Remember that evaporation below the boiling-point can be rapidly accomplished only by constant stirring. If the dish is left on water-bath without stirring, the evaporation will be very slow.

Finishing.—The soft extract is dissolved in the reserve portion, and the mixture poured into a graduate. The evaporating dish is washed out with about 5 mils diluted alcohol, and this poured into the graduate, and then enough diluted alcohol is added to make finished fluidextract measure 50 mils. The mixture is thoroughly stirred, and so made constitutes Fluidextract of Gentian, U.S.P.

Remarks.—*The weak percolate is evaporated to soft extract*—most of the water is driven from it—lest that water precipitate some of the principles dissolved in the reserved portion.

The *finished fluidextract* is usually filtered after standing some months. All large manufacturers let their fluidextracts thus "age" for from six months to a year, so that when bottled and shipped, no further precipitation is apt to occur.

MAKE FLUIDEXTRACT GENTIAN BY REPERCOLATION

The method of making fluidextract by repercolation is given because of its historical interest. The writer (Arny and Oxley, A.Ph.A., 58, 1910, 1104) has shown that in the hands of the average worker, the process of repercolation does not yield a product, 1000 mils of which represents 1000 grammes of drug. Recognizing this fact the present pharmacopœia does not recommend the use of repercolation in making fluidextracts but suggests a variety of fractional percolation. For details see U.S.P., p. 175 and also p. 242 of this book.

The Process.—Weigh out 50 Gm. of the drug allotted, moisten it with 50 mils of the menstruum directed by the U.S.P., and macerate in an 8-ounce wide-mouthed bottle for the time directed by the pharmacopœia, At the end of this time pack in percolator, as directed on p. 161, and percolate exactly as there described, with one exception. This exception is the caring for the successive portions of the percolate by putting it in separate bottles. Clean and label six bottles. An 8-ounce bottle label "Finished Fluidextract;" four-ounce bottles labeled "weak percolate No. 1," "weak percolate No. 2," "weak percolate No. 3," "weak percolate No. 4," respectively. Lastly, a pint bottle labeled "weak percolate No. 5."

Collect the percolate in an 8-ounce wide-mouthed bottle, previously measured and marked 40 mils and 50 mils by scratching with a file, Pour the first 40 mils of precolate into "finished fluidextract" bottle, the next 50 mils in "weak percolate No. 1" bottle, and the following 50 mils portions into "weak percolate No. 2, 3, and 4" bottles, respectively. Lastly, percolate the drug to exhaustion, collecting all this percolation into "weak percolate No. 5" bottle.

When "weak percolate No. 1" and "weak percolate No. 2" are collected, a second batch of 50 Gm. of drug is weighed and moistened with "weak percolate No. 1;" macerate it the required time, pack in percolator, and pour on "weak percolate No. 2." When this has almost all run through, add "weak percolate No. 3," then "weak percolate No. 4," then "weak percolate No. 5," and, lastly, menstruum enough to exhaust.

Collect the percolate in the 8-ounce wide-mouthed receiving bottle and put, first, 50 mils of percolate into "finished fluidextract" bottle the second 50 mils, into now empty "weak percolate No. 1" bottle, the next into "weak percolate No. 2" bottle, the fourth and fifth 50 mils batches into bottles Nos. 3 and 4, and the rest of the percolate to exhaustion in "weak percolate No. 5" bottle. When "weak percolate No. 1" and "weak percolate No. 2" from the second batch of drug are obtained, weigh out a third batch of 50 Gm. drug and treat it exactly as you did the second batch. When this third batch has been percolated far enough, that is, when weak percolates Nos 1. and 2 have been obtained from it, get a fourth batch of 50 Gm. drug started, macerating and percolating, making it exactly as you did batches Nos. 2 and 3.

When this fourth batch of drug is exhausted, the operation is at an end, and we will have, as the result, 40+50+50+50, or 190 mils finished fluidextract from the 200 Gm. of drug and weak percolates Nos. 1, 2, 3, 4, and 5.

These weak percolates are to be securely corked and placed in a safe, cool place, there to rest until more of the same fluidextract is needed. Then they are to be taken out, a new batch of 50 Gm. of drug weighed out and macerated and percolated, exactly as before, and the process repeated three times, thus making 200 mils finished fluidextract from the 200 Gm. of drug.

MAKES PILLS OF ACETANILIDE

Powdered acetanilide	1 Gm.

Put on pill-tile, and bring in contact with a spatula containing a sufficient amount of excipient. Knead the excipient into the powder by means of the spatula until a pliable pill mass is obtained. Scrape the mass into one lump, dust the pill-tile with powdered starch, roll the pill mass out with the spatula into a cylinder like a pencil until it is the length of ten divisions on the scale on the tile. Then cut the cylinder with spatula into ten equal parts, and roll each between *clean* thumb and forefinger until perfectly spheric. Then put in pill box, dust with starch, wrap box in paper, making a neat package (p. 288).

Remarks.—*Excipient.*—Substance used to make drugs, liquids as well as solids, into plastic mass (p. 304).

A good excipient for powders is glycerite of tragacanth:

Powdered tragacanth	3 drachms
Triturate with glycerin	3 fluidrachms
Then add water	½ fluidounce.

Transfer jelly into appropriate jars.

The *amount of excipient required* can be learned only by experience. Roughly speaking, in above case a lump about the size of a pea should suffice. To make a good mass the entire amount of excipient required should be added at one time.

If mass is too soft, add another 1 Gm. powdered acetanilid and make 20 pills.

Masses are made on tiles only when small amounts of pills are to be made, and when there is no difficulty in forming the mass.

Pliable Pill Mass.—See p. 304.

Cutting pills on tile with spatula gives irregular results. Every drugstore should have a pill-cutter. (See p. 306.)

Pills are dusted to prevent their sticking together. White pills should be dusted with powdered starch; dark pills, with lycopodium.

MAKE COMPOUND CATHARTIC PILLS

Recipe.—**Compound extract of colocynth**	**2.00 Gm.**
Mild mercurous chloride	**1.50 Gm.**
Resin of jalap, in fine powder	**0.50 Gm.**
Gamboge, in fine powder	**0.37 Gm.**
Diluted alcohol, a sufficient quantity,	
To make ...	**25** pills.

Mix the powders intimately, then incorporate a sufficient quantity of diluted alcohol to form a mass, and divide it into 25 pills.

Remark on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student. In *triturating powders* always first rub up the ingredients prescribed in smallest amount with a small quantity of the other substances, and add the rest of the drugs gradually with constant stirring—this to insure thorough blending of the most potent drugs.

The *excipient* in this case is diluted alcohol, the compound extract of colocynth containing soap and aloes, which combine with the water to make a plastic mass. Five drops should suffice, provided enough "elbow grease" is used. In fact, if the mortar is warmed and the pestle is handled vigorously, the mass can be formed without use of diluted alcohol.

Working up the mass in a mortar with a pestle is a process hard to explain by words. The pestle is firmly grasped in the right hand with the end of the handle resting against the center of the palm, while the mortar is held fast with the left hand. The mass is worked by pressing down on it with the pestle with a rotary movement to the right. From time to time the mass is carefully scraped from the pestle and from the sides of the mortar and worked again, the process being continued until a thoroughly plastic mass results.

Cutting the cylinder into pills must be done indirectly when the scale on the pill-tile is for ten or twenty pills, if twenty-five pills are directed. If the scale has twenty markings, roll the cylinder out to twenty and cut into five equal lengths (four spaces each). Then take each length and roll until it is five spaces long, and cut into five pills. Treating the other lengths similarly, we have in the end twenty-five pills. It is needless to say that great care should be taken to have the cylinder of exactly the same thickness through its entire length.

Roll pills between the first finger and thumb as in making pills of acetanilide.

Dust pills with lycopodium.

MAKE PILLS OF PHOSPHORUS

Recipe.—**Phosphorus**	**0.015 Gm.**
Althæa, in No. 60 powder	**1.500 Gm.**
Acacia, in fine powder	**0.750 Gm.**
Chloroform,	
Glycerin,	
Water,	
Balsam of Tolu,	
Ether, each, a sufficient quantity,	
To make ...	**25** pills.

Dissolve the phosphorus, in a test-tube, in 1¼ mils of chloroform, with the aid of a very gentle heat, replacing from time to time any of the chloroform which may be lost by evaporation. Mix the althæa and acacia in a mortar, next add the solution of phosphorus, then immediately afterward a sufficient quantity (about 1 mil) of a mixture of two volumes of glycerin and one volume of water, and quickly form a mass; divide it into 25 pills.

Dissolve 10 Gm. balsam of Tolu in 15 mils of ether, shake the pills with a sufficient quantity of this solution until they are uniformly coated, and put them on a plate to dry, occasionally rolling them about until the drying is completed.

Keep the pills in a well stoppered bottle.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Handling the phosphorus must be done with care, as it is very unstable, igniting spontaneously when exposed too long to the air. Phosphorus should always be weighed *under water*, that is, a beaker or other vessel containing water should be counterpoised on the scale, and the phosphorus immersed in water while weighing. In the same way the large piece of phosphorus should be cut while under water contained in pint evaporating dish.

The *cutting of phosphorus* is easy, since it is a soft, waxy solid, readily sliced with an ordinary knife. Always cut off the outer oxidized layer, and use the fresh phosphorus from the middle of the stick.

The *solution of phosphorus* is made by quickly freeing the weighed phosphorus from adhering water by pressing between filter-paper and dropping the lump into the chloroform contained in a test-tube before the phosphorus has time to ignite. If the phosphorus dissolves slowly in the chloroform, the solution can be aided by the use of gentle heat, adding extra chloroform to make up for loss of evaporation.

The *mass must be worked up* as rapidly as possible lest it *catch fire.* If it does ignite, carry to sink and turn on the water from the faucet.

Use enough excipient to make a rather soft mass, for a firm mass becomes rubber-like on rolling out. Ten to twelve drops usually suffice.

In cutting the pill cylinder use the same plan as with compound cathartic pills if the pill-tile scale has not twenty-five spaces. Use lycopodium as a dusting-powder.

Coating the pills does not yield handsome results; in fact, no pill coating can be well done without special appliances. (See p. 308.) In this special case the coating is not put on to enhance the appearance of the pill, but to protect it from atmospheric action (p. 312). In coating, put pills in small dish, pour on ten to twenty drops of the tolu solution, and rotate until dry. Then, if necessary, add more tolu solution and rotate further.

PUT UP CONSEALS

Pulverized sugar.................................. 6 Gm.

Put up in six conseals (No. 1 size) by directions found on conseal apparatus. (See p. 297.)

MAKE LOZENGES OF POTASSIUM CHLORATE

Recipe.—	**Potassium chlorate,** in fine powder	**1.8 Gm.**
	Sugar, in fine powder	**7.2 Gm.**
	Tragacanth, in fine powder	**0.36 Gm.**
	Water, a sufficient quantity,	
	To make..	**12** troches.

Mix the sugar with the tragacanth by trituration in a mortar; then transfer the mixture to a sheet of paper, and by means of a bone spatula mix with it the potassium chlorate, being careful to avoid unnecessary trituration or pressure which might cause the mixture to ignite or explode. Lastly, form a mass with water and divide into twelve troches.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Beware of trituration of dry potassium chlorate with sugar or other oxidizable substances, as a frightful explosion is apt to occur. Hence the pharmacopœia directs mixing these ingredients on paper with bone spatula. A metallic spatula can be used, however, if one is cautious in the manipulation.

Working the powders into a mass can be safely done with mortar and pestle, provided the mass is well moistened. Do not use too much water, however, lest a very soft mass results—1 mil should suffice.

Roll out the mass as if it were biscuit dough, but do not roll too thin. In making twelve lozenges the mass is generally rolled out broad enough comfortably to cut eight lozenges. The scraps are then worked up and rolled out so that three lozenges can be cut, and the scraps now remaining should be just enough to make the twelfth lozenge—no more, no less.

Both pills and lozenges should be air-dried before putting away. If bottled while moist, they will grow moldy.

MAKE BELLADONNA SUPPOSITORIES

Extract of belladonna	0.32
Oil of theobroma	10.00

Make five suppositories.

Weigh the extract out on a piece of paper and transfer by means of a spatula to the point of the pestle, and make into paste with about five drops water in a warm mortar.

In the meanwhile melt the oil of theobroma in small evaporating dish on water-bath, and when completely fused, pour about one-tenth of the oil into warm mortar containing the extract. Triturate until a complete blending of the oil and the extract takes place, and then transfer the still liquid mass into the rest of the oil of theobroma in the dish, carefully scraping all from mortar and pestle by means of spatula.

Mix the extract thoroughly with the molten oil of theobroma by stirring the glass rod, and remove from water-bath, and when the first signs of congealing show, pour the mixture into the thoroughly chilled molds, keeping the extract suspended by constant stirring while pouring into mold. Then let mold stand quietly on the ice until solidification is complete, after which remove the suppositories from the mold.

Remarks.—The *extract* used in suppositories should be soft extract, not the powdered form.

Fusing the oil of theobroma should be at a low temperature. Heating too high gives the mass a fried smell.

Do not pour into molds while the mass is hot. Just before it congeals is the proper time.

Stir mass while pouring, else the extract will not be uniformly distributed.

Have molds on ice at least a half-hour before pouring mass in. To get good results, the molds must be thoroughly chilled.

Have interior of molds perfectly dry and clean when mass is poured in. If such is the case, there is no need of using lycopodium to dust inside of mold.

The *mass, on congealing,* if molds are well chilled, contracts and loosens from molds with smooth, shining surface. In this case *suppositories can be removed from mold* by gentle tapping. If they stick, slight downward pressure from the top usually loosens them. If they stick more tenaciously, the molds must be cautiously opened and the suppositories removed by pressing from tip upward.

If the suppositories stick to mold, it is due either to insufficient chilling of molds before melted mass is poured in or to dirtiness of molds.

Most suppository molds hold 20 grains of oil of theobroma. This must be considered in making suppositories and the amount of oil of theobroma added in making the mass should be just enough to fill the molds.

MAKE SUPPOSITORIES BY HAND

Oil of theobroma	8 Gm.
Castor oil	q.s.

Grate or slice the oil of theobroma in thin shavings and put into mortar; add about five drops of alcohol and thus pulverize by intervention. Then add five drops castor oil and work into mass as if making pills. Place finished mass on pill-tile, dust with lycopodium, and roll out to mark 8 on scale on pill-tile. Cut the cylinder in half and shape each half into a double cone by rolling gently with spatula. Then cut each double cone in half, and we have *four* suppositories.

Remarks.—This method does not yield as handsome a product as those made by fusion, but it has the advantage of being applicable in all cases.

Avoid contact of the mass with the hand, as the oil of theobroma melts at temperature of the body.

In shaping the suppository, if found more convenient, the mass can be directly divided into four parts by measuring on pill-tile or by weighing, and each part made into a cone.

These pure butter of cocoa suppositories are given merely for practice. Of course, in actual business, they will be directed blended with some medicinal constituents.

MAKE COMPRESSED SUPPOSITORIES

Take oil of theobroma q.s. (say 10 Gm.). Powder with alcohol, put into suppository machine, and press into both the rectal and the bougie mold. For picture of mold, see p. 326.

Remarks.—Note what is said just above as to fact that in actual business the oil of theobroma is always prescribed combined with some medicinal constituent.

MAKE GLYCERIN SUPPOSITORIES

Recipe.—	**Glycerin**	**6.00 Gm.**
	Monohydrated sodium carbonate	**0.10 Gm.**
	Stearic acid	**0.40 Gm.**
	Water	**1.00 mil**
	To make	**2** suppositories.

Dissolve the monohydrated sodium carbonate in the water and add it to the glycerin, contained in a dish, on a water-bath; add the stearic acid, and heat the mixture carefully until carbon dioxide ceases to be evolved and the liquid is clear. Then pour the melted mass into suitable molds, remove the suppositories when they are completely cold, and preserve them in tightly stoppered glass vessels.

Remark on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student. The manufacture of these suppositories involves a chemical action, the sodium carbonate reacting with the stearic acid to form sodium stearate, and with this the glycerin blends, thereby producing a solid suppository containing about six-sevenths its weight of glycerin.

Weigh the glycerin in small evaporating dish, and to it add the sodium carbonate and later the stearic acid.

Be sure the sodium carbonate is crystalline and monohydrated. The efflorescent salt works poorly.

Shave the stearic acid into thin pieces with knife or spatula before putting into glycerin.

Heat Carefully.—Experience shows, however, at this stage, that the heat of a water-bath scarcely suffices, so when the sodium carbonate is dissolved, remove from water-bath to wire gauze, dry the bottom of dish, and heat *very cautiously* until reaction ceases. *Until escape of carbonic acid gas has ceased.*

Sodium carbonate plus stearic acid or any other acid gives off CO_2 gas, and forms a salt of the added acid.

Stir very slightly in making, and that only with glass rod, merely enough to aid the CO_2 in escaping. If stirred vigorously, the mass will become mixed with air and will not be clear.

The *mass must be clear* when poured into molds, else the finished suppositories will be opaque.

Pour into Suitable Molds.—Note that the finished suppository will weigh over 3 Gm., about twice the ordinary rectal suppository. Hence the ordinary mold will not do. For practice, however, the mass may be poured into the smaller mold, thus making a suppository half the official size. In this case, as in belladonna suppositories, the mold must be thoroughly chilled by placing on ice, and the mass must be almost ready to congeal when poured in.

Removing these suppositories from the mold by tapping will not work; the molds must be opened and the suppositories removed by pressing from tip upward.

MAKE COLD CREAM

Recipe.—**Spermaceti**	**6.25 Gm.**
White wax	**6.00 Gm.**
Expressed oil of almond	**28.00 Gm.**
Sodium borate, in fine powder	**0.25 Gm.**
Stronger rose water	**9.50 Gm.**
To make about..	**50 Gm.**

Reduce the spermaceti and the white wax to fine shavings, and melt them at a moderate heat; add the expressed oil of almond and stir, continuing the heat until the mixture is uniform; then gradually add the stronger rose water, previously warmed, and in which the sodium borate has been dissolved, stirring the mixture rapidly and continuously until it congeals and becomes of uniform consistence.

When this ointment is to be used as a vehicle for metallic salts, the sodium borate should be omitted.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Melt the spermaceti and white wax in pint evaporating dish, and to it add the oil of almond.

Dissolve the borax in the rose water in Erlenmeyer flask, and this solution should be almost as warm as the mixed fats. If it is cold, the spermaceti will separate as if curdled.

Do not warm the rose water enough to drive off its odor, however. The finished cold cream is not highly perfumed. If more odor is desired, add—

Oil rose	10 drops	to each pound.
Oil lemon	6 drops	
Oil bergamot	4 drops	

The oils should be added, not alcoholic solutions of them.

This cold cream turns rancid quickly, and should, therefore, be sold only when fresh. For a permanent cold cream white paraffin oil is substituted for oil of almond. *This substitute must not, however, be dispensed as an official cold cream.*

MAKE BLUE MASS

Recipe.—**Mercury**	**3.3 Gm.**
Glycyrrhiza, in No. 60 powder	**1.0 Gm.**
Althæa, in No. 60 powder	**1.5 Gm.**
Glycerin	**0.9 Gm.**
Honey of rose	**3.3 Gm.**
To make	**10 Gm.**

Triturate the mercury with the honey of rose until it is extinguished, and globules of mercury are no longer visible under a lens magnifying at least ten diameters. Add the glycerin, then the glycyrrhiza and altheæ gradually, and continue the trituration until the mass is homogeneous. Keep the product in well-closed containers.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Triturate the mercury with the honey of rose in a mortar until extinguished—that is, until no mercury globules are seen and a thin gray paste results. If trituration is stopped, however, the mercury will run together.

Add the rest of the honey, the glycerin and the powdered drugs and then triturate vigorously. This has the effect of coating each globule of mercury with the powder, thus preventing one from running into the other.

Triturate until no globules are seen under glass magnifying ten diameters—that is, making things look ten times their real size. To accomplish this usually takes a half hour's trituration.

MAKE EMULSION OF COD LIVER OIL

(By Continental Method)

Cod liver oil	30 mils
Water	15 mils
Powdered acacia	7.5 Gm.
Water, syrup, and flavor, to make	60 mils

Put the acacia in a dry mortar and add all the oil, triturating the mixture well. Then add the water (15 mils) all at once and triturate vigorously until a creamy emulsion results. Lastly, add syrup 5 mils, flavor to taste, and add water to make 60 mils.

Remarks.—The theory of emulsions is similar to that of making blue mass and other preparations of free mercury, the oil being broken into fine globules by trituration and each globule immediately coated with a layer of gummy substance, thus preventing adjacent globules from running together.

The two methods of emulsification are called the English and the Continental processes (see p. 260), and the above recipe is by the Continental process, and practically that recognized by the present pharmacopœia (p. 137).

Note the proportions essential to a successful Continental emulsion: 4, 2, and 1; 4 parts of oil, 2 parts of water, and 1 part of gum.

For flavor, the pharmacopœia directs $^{4}/_{10}$ of 1 per cent. of methyl salicylate gaultheria, or an appropriate quantity of any other flavor may be used. The finished acacia emulsion is almost too thick for practical use and contains too large amount of acacia.

The *English emulsion* can be made from less gum, the sole advantage the process possesses.

When oil, gum, and water are triturated a few minutes, a white emulsion should result, the desired effect being indicated by a characteristic crackling sound as the mixture is triturated. If this crackling sound is not heard, and if the mixture has a greasy, "pearly" appearance, it means that the oil is not emulsified—that the emulsion is "split."

Do not Throw Away a Split Emulsion.—Make up another batch as a nucleus, and gradually incorporate the split emulsion, when the entire quantity will be emulsified. There is no better emulsifier than a good emulsion.

MAKE FLASK EMULSION OF COD LIVER OIL

Powdered tragacanth	1 Gm.
Gelatin, in No. 80 powder	1 Gm.
Cod liver oil	20 mils
Water, flavor, etc., to make	40 mils

Put the powders in a dry Erlenmeyer flask, add the oil and shake, then add 15 mils water, and shake when an emulsion results.

Remarks.—This formula was devised to replace a class of flask emulsifiers introduced a few years since, and containing the two questionable substances—saponin and saccharin.

It is given merely as an illustration of this kind of work and is not recommended. To make a good emulsion one should be willing to dirty a mortar.

It also shows that almost any gummy substance can be used as an emulsifier.

MAKE EGG EMULSION OF COD LIVER OIL

Glycerite of yolk of egg (U.S.P. 1890)	10 mils
Cod liver oil	30 mils
Syrup	6 mils
Brandy	10 mils
Water	4 mils

Pour the glycerite into mortar, and add the oil little by little, with constant trituration until completely emulsified. Then add the other ingredients in the order named.

Remarks.—This preparation is emulsified by use of yolk of egg, an emulsion of egg fat with the albuminoids. It is an illustration of the dictum, "the best emulsifier is a perfect emulsion."

Be careful to add oil gradually, else the emulsion may split. The addition of the last portions of oil may make the product almost too stiff to work, in which event add a few drops of water, say, 1 mil. *In laboratory work* omit the brandy from this recipe.

The best flavor for this is a compound tincture of cardamom *not colored* with cochineal. One-half mil suffices with the above quantity.

MAKE EMULSION OF TURPENTINE

Powdered tragacanth	2 Gm.

Put in dry 8-ounce wide-mouthed bottle, corked and add—

Oil of turpentine	16 mils
Then add water	30 mils and shake.

The finished emulsion can be diluted with water and flavored to any strength directed by the physician.

Remarks.—This is not the recipe provided by the present pharmacopœia for official emulsion of oil of turpentine (p. 263), in which acacia is used as the emulsifying agent, and expressed oil of almond used to make a more stable emulsion.

CHAPTER LX

CHEMICAL PREPARATIONS

MAKE SOLUTION OF SODA, U.S.P., 1890

Recipe.—Sodium carbonate	42.5 Gm.
Lime	12.5 Gm.
Distilled water, a sufficient quantity.	

Dissolve the sodium carbonate in 100 mils of boiling distilled water. Slake the lime with about 7½ mils of distilled water, then mix it well with 100 mils of distilled water, pour the mixture into a tared flask, and, having heated it to boiling, gradually add to it the solution of sodium carbonate and boil during ten minutes. Then add enough distilled water to the flask to make the contents weigh 250 Gm., and set the flask aside, well stoppered, until the contents are cold. Lastly, strain the liquid through linen, set it aside in a well-stoppered bottle until it has become clear by subsidence, and separate the clear solution by decantation or by means of a siphon.

Explanation.—Monohydrated sodium carbonate, U.S.P. IX, 18.4 Gm. can be used instead of the above amount of crystalline sodium carbonate. The chemical reaction in this process is as follows:

$$Ca(OH)_2 + Na_2CO_3 = NaOH + CaCO_3.$$

The result of the reaction is a liquid containing sodium hydroxide in solution, and a sediment consisting of calcium carbonate (precipitated chalk).

The equation given above is purposely left incomplete. Complete this so that the amount of each element on the two sides of the sign of equality is the same.

Again, the equation does not represent the truth as far as the constituents directed by the U.S.P. is concerned. Lime is not calcium hydroxide, but is calcium oxide, the hydroxide being produced only after shaking the lime, the reaction being $CaO+H_2O=Ca(OH)_2$.

Again, the sodium carbonate directed above is not the exsiccated Na_2CO_3, but the crystalline salt containing ten molecules of water of crystallization. So the real reaction runs:

$$CaO + H_2O + Na_2CO_3 10H_2O = NaOH + CaCO_3.$$

Be sure to complete this equation before proceeding further. (See p. 400.)

Calculations.—Figure out molecular weight of the five substances in above equation, viz.:

Ca atomic weight = ——	Ca = 1 × —— = ——.
O atomic weight = ——	O = 1 × —— = ——.
	CaO molecular weight = ——.

H atomic weight = ——	H_2 = 2 × —— = ——.
O atomic weight = ——	O = 1 × —— = ——.
	H_2O molecular weight = ——.

Na atomic weight = ——	Na_2 = 2 × —— = ——.
C atomic weight = ——	C = 1 × —— = ——.
O atomic weight = ——	O_3 = 3 × —— = ——.
H_2O molecular weight = ——	$10H_2O$ = 10 × —— = ——.
	$Na_2CO_3 10H_2O$ molecular weight = ——.

Na atomic weight = ——	Na = 1 × —— = ——.
O atomic weight = ——	O = 1 × —— = ——.
H atomic weight = ——	H = 1 × —— = ——.
	NaOH molecular weight = ——.

NaOH molecular weight = ——. The actual weight of NaOH produced from above equation is this molecular weight *times* the number of molecules produced

Ca atomic weight = ——	Ca = 1 × —— = ——.
C atomic weight = ——	C = 1 × —— = ——.
O atomic weight = ——	O_3 = 3 × —— = ——.
	$CaCO_3$ molecular weight = ——

Now write the equation last given with the correct number of molecules, and place under each substance the figures expressing the molecular weights, or, in case more than a molecule of a substance is involved, the combining weights. Then reckon out the following problems:

1. How many grammes absolute sodium hydroxide in 250 Gm. of 5 per cent. solution of soda?
2. How many grammes of lime (CaO) and of crystallized sodium carbonate ($Na_2CO_3 + 10H_2O$) needed to make 80 Gm. absolute soda (NaOH)?
3. How many grammes of lime and of crystalline sodium carbonate needed to make 12.5 Gm. absolute soda?

If monohydrated sodium carbonate is used, the equation will run:

$$CaO + H_2O + Na_2CO_3H_2O = NaOH + CaCO_3.$$

(Complete this equation).

The molecular weight calculation, as far as the sodium carbonate is concerned, will be:

Na atomic weight ——	Na_2 = 2 × —— = ——.
C atomic weight ——	C = 1 × —— = ——.
O atomic weight ——	O_3 = 3 × —— = ——.
H_2O molecular weight ——	H_2O = 1 × —— = ——.
	$Na_2CO_3H_2O$ molecular weight = ——.

For table of atomic weights, see p. 352.
For complete figuring of molecular weights, see p. 363.
For details of balancing equations, see p. 400.

Remarks on Process.—*Dissolve the sodium carbonate* in pint flask, and when solution is complete, put into an 8-ounce wide-mouthed bottle. Filter only if necessary—if containing dirt.

Be sure that the sodium carbonate is not effloresced. For this reason the non-efflorescent monohydrated sodium carbonate is better.

Slake the lime by placing a lump in a mortar and adding the water, drop by drop, so it can be absorbed by the lime.

Better do this before dissolving the sodium carbonate, as with the small amount of lime used the slaking will take some time. Do not expect the generation of a large amount of heat in slaking the minute quantity of lime. Heat *is* developed, but in scarcely appreciable quantity. Slaking of the lime may be hastened by warming mortar on radiator.

When the lime is slaked, it will crumble to a powder. This takes, with the small amount of lime employed, fifteen minutes to a half-hour. When lime is slaked, *mix it well with water.* That is, triturate with, say, 75 mils of the water, making a milky paste (milk of lime); pour this into flask, and wash mortar and pestle with the other 25 mils water, pouring washings into flask containing the milk of lime.

Be sure to tare flask before pouring in the milk of lime. The rest of the directions given above need no special remarks, except the statement that—

The *finished product is not to be filtered:* at least, through paper, as the alkali will eat the paper. Asbestos wool can be used, however, a bit of this inserted into funnel as if it were a plug of cotton. The pharmacopœia, however, directs decantation.

The *precipitated chalk is to be thrown away,* as it cannot be freed from the alkali except by extraordinary effort.

MAKE SOLUTION OF CHLORINATED SODA

Recipe.—	**Monohydrated sodium carbonate**	**6.5 Gm.**
	Chlorinated lime	**9.0 Gm.**
	Water, a sufficient quantity,	
	To make	**100 Gm.**

Triturate the chlorinated lime (which should contain not less than 30 per cent. of available chlorine) with 20 mils of water, gradually added, until a uniform mixture results. Allow the heavier particles to subside, and transfer the thinner, supernatant portion to a filter. Then triturate the residue again with 20 mils of water, transfer the whole to the filter, and, when the liquid has drained off, wash the filter and contents with 10 mils of water. Dissolve the monohydrated sodium carbonate in 30 mils of hot water, and add this solution to the previously obtained filtrate contained in a suitable vessel. Stir or shake the mixture thoroughly, and, if it should become gelatinous, warm the vessel very gently until the precipitate subsides. Then transfer the mixture to a new filter, and, when no more liquid drains from it, wash the filter and contents with enough water to make the product weigh 100 Gm. Keep the solution in well-stoppered bottles, protected from light, and in a cool place.

Explanation.—The chemical reaction involved in the above process runs in two equations, since the chlorinated lime employed is a mixture of calcium hypochlorite and calcium chloride:

Equation A:

Calcium		Sodium		Calcium		Sodium
hypochlorite	plus	carbonate	give	carbonate	plus	hypochlorite
$Ca(OCl)_2$	+	Na_2CO_3	=	$CaCO_3$	+	$NaOCl$.

Equation B:

Calcium		Sodium		Calcium		Sodium
chloride	plus	carbonate	give	carbonate	plus	chloride
$CaCl_2$	+	Na_2CO_3	=	$CaCO_3$	+	$NaCl$.

The result of the reaction is a liquid containing sodium hypochlorite and sodium chloride in solution and calcium carbonate (precipitated chalk) as a sediment.

The *equations given above are purposely left incomplete*. Complete these, so that the amount of each element on the two sides of the sign of equality is the same.

Calculations.—Chlorinated lime, being of variable quality, the molecular quantities cannot be conveniently worked out.

However, figure out:

How many grammes of chlorine in 9 Gm. of 30 per cent. chlorinated lime?

How many grammes of chlorine in 100 Gm. of 2.4 per cent. solution of chlorinated soda?

Comparison of these figures will show that the pharmacopœial process anticipates the conversion of the chlorinated lime into solution of chlorinated soda with the loss of but 10 per cent. of the volatile chlorine—a thing that is thoretically possible, but rarely practically attained.

Remarks on Process.—The recipe of the present pharmacopœia differs from the one given above in the fact that chlorinated lime is made into a paste with water and to this unfiltered paste the sodium carbonate solution is added, after which the mixture is filtered. This improvement was suggested by the writer and his co-workers. (See bibliography on p. 388.)

Put chlorinated lime in mortar and triturate with the water.

The *thinner supernatant portion* (see p. 142) contains the soluble part of the chlorinated lime, and this is passed through the filter first. This is an illustration of decantation.

The *heavier particles* are triturated with more water, adding the water gradually with firm pressure of the pestle in order to reduce particles to a pasty condition.

Pour the entire paste on the filter, and thus dissolve the soluble portion left in the chlorinated lime after the first washing.

Use the last 10 *mils water* to wash out mortar and to extract the insoluble part of the chlorinated lime contained on the filter.

Dissolve the sodium carbonate in the water in pint flask, and to this add the chlorinated lime filtrate.

If gelatinous, warm, but that only slightly, lest a large amount of chlorine be driven off.

Filter mixture into a tared 8-ounce wide-mouthed bottle. Both solution of chlorinated soda and also chlorinated lime contain chlorine in a form so loosely combined that the gas easily escapes. Hence in the entire process care should be taken to avoid undue exposure, either to the air or to heat.

MAKE AMMONIUM SULPHATE

Ammonia water (10 per cent.)	**340 grains or —— gm.**
Diluted sulphuric acid (10 per cent.)	**980 grains or —— gm.**

Place the ammonia water in a pint evaporating dish, add the sulphuric acid gradually until faintly acid to litmus-paper, using more than the amount given above if necessary.

Then add extra ammonia water, drop by drop, until alkaline to litmus-paper. Place dish on wire gauze and evaporate to dryness.

Explanation.—This process gives us an illustration of a simple reaction, viz.: ammonia plus sulphuric acid gives ammonium sulphate.

Express this reaction by equation, writing the formula of each of the compounds mentioned above and the number of molecules of each substance entering the equation.

Calculations.—Next work out molecular weight of each of the above compounds (as shown in solution of soda), and through these molecular weights answer the following problems:

1. How many grammes ammonia gas and absolute sulphuric acid are needed to make 132 grains of ammonium sulphate?

2. How many grains of 10 per cent. ammonia water and of 10 per cent. sulphuric acid are needed to make 132 grains of ammonium sulphate?

Remarks on Process.—*Convert grains into grammes* by dividing by 15.432.

Add the acid gradually to the ammonia, as the reaction is apt to be quite violent.

Litmus-paper (see p. 358).

In testing with litmus-paper dip a glass rod into the liquid and thus bring one drop of the liquid on the piece of litmus-paper moistened with water. Never dip the litmus-paper into the mixture.

Add acid until faintly acid—that is, it may chance that the theoretic quantities given above may not yield exact results, due to some variation in strength of either acid or alkali. In such cases we therefore look for *results* rather than figures, and use an extra quantity of the ingredients to get the results, if necessary.

Thus, if after adding the directed quantity of acid, the mixture is still alkaline (until a drop turns red litmus blue), add acid until faintly acid (turns blue litmus red).

Usually, after the acid is added, the reaction will be distinctly acid, as the ammonia is more apt to lose strength on standing than is the acid. If such is the case, add ammonia until the mixture is distinctly alkaline—until a drop turns red litmus-paper blue.

Be sure to have evaporating mixture alkaline. An excess of acid will spoil the product; an excess of alkali will have no hurtful result, since the excess of ammonia will be driven off as the salt reaches dryness.

Evaporate to dryness, but do not continue heat after dryness—as the ammonium sulphate is volatile.

MAKE AMMONIUM IODIDE

Potassium iodide	½ troy ounce or	——Gm.
Ammonium sulphate	109 grains or	——Gm.
Water	¼ fluidounce or	——mils

Put salts in Erlenmeyer flask, add the water while boiling, stir well, and let cool. Then add 1 drachm alcohol, cool the mixture with ice or running water, and throw the mixture on funnel plugged with cotton. When the liquid has filtered through, wash precipitate with 1 drachm of a mixture, consisting of alcohol, 1 part, water, 2 parts. Then put filtrate in pint evaporating dish, and evaporate solution rapidly to dryness, stirring constantly.

Explanation.—In this process a double decomposition occurs between the potassium iodide and ammonium sulphate, whereby potassium sulphate and ammonium iodide are formed.

Equation:

$KI + (NH_4)_2SO_4$

Complete this equation.

Calculation.—Figure out molecular weights of each of the above substances, and from the molecular weights learn the weights by which the two chemicals combine. Then solve the following problems:

1. How much potassium iodide and ammonium sulphate are needed to make 290 grains of ammonium iodide?
2. How much potassium iodide and ammonium sulphate are needed to make 218 grains of ammonium iodide?

Compare these figures with above recipe, and see how closely they agree.

Remarks on Process.—Looking at the explanation of the chemistry of the process, we see that the products of the reaction between potassium iodide and ammonium sulphate are potassium sulphate and ammonium iodide. Now it chances that both of these chemicals, like the substances from which they are made, are soluble in water. How are we to obtain the ammonium iodide we desire free from the potassium sulphate?

In all manufacturing chemistry effort is made to get all the *reaction* products save the one we desire in some form different from the one we want.

Thus, in making solution of soda, we choose as the sodium ingredient sodium carbonate, knowing that that would produce with the lime insoluble calcium carbonate, thus leaving the soda itself in the solution, free from any other substance. Again, if we want an insoluble body, say, precipitated chalk, we try to get the other reaction products in a soluble form. (See p. 456.)

In the ammonium iodide we cannot think of any salt we can use that will obtain for us the second reaction product in insoluble form. Every combination we think of will yield some chemical soluble in water, even as is ammonium iodide. Therefore, we have to devise some way of separating the iodide from the potassium sulphate, and we accomplish this by use of alcohol, in which the iodide is freely soluble, while the sulphate dissolves but slightly.

Filter through funnel plugged with cotton, even as you did granulated ferrous sulphate. (See p. 973.)

Evaporate rapidly, as the product is quite unstable, easily giving up its iodide and becoming brown. For this reason, during evaporation, it is advisable to add a drop of ammonium sulphide test solution, from time to time, to prevent decomposition.

MAKE PRECIPITATED CHALK

Marble	10 Gm.

Put in beaker and add a mixture of—

Hydrochloric acid	23 Gm.
Water	45 mils.

Watch effervescence, and when solution is complete, filter into another **beaker**. Then add a solution of:

Monohydrated sodium carbonate	12.4 Gm.
Water	90 mils

Stir, let precipitate subside, then decant supernatant liquid, add more water, and finally precipitate on to a plain filter and continue washing until wash liquor no longer gives precipitate with either calcium chloride solution or silver nitrate solution. Then let precipitate dry.

Explanation.—This process is in two stages.

First, the insoluble marble (crude calcium carbonate) is dissolved in hydrochloric acid, forming soluble calcium chloride with the evolution of carbon dioxide, viz.:

Equation A:

Calcium carbonate	plus	Hydrochloric acid	give	Calcium chloride	plus	Carbon dioxide	plus	Water.
$CaCO_3$	+	HCl	=		+		+	

Complete this equation.

The dissolving of marble by hydrochloric acid is for the purpose of purification, it being easier to purify substances when in solution than in solid form. The solution of calcium chloride is then treated with sodium carbonate, when calcium carbonate (precipitated chalk) separates out, while sodium chloride goes into solution.

The reaction is:

Equation B:

Calcium chloride	plus	Sodium carbonate	give	Calcium carbonate	plus	Sodium chloride.
$CaCl_2$	+	$Na_2CO_3H_2O$	=		+	

Complete this equation.

Calculations.—First, the manufacture of calcium chloride. Work out the molecular weights of calcium carbonate, hydrochloric acid, and calcium chloride, and place under equation given above. Then solve the following problems:

1. How many grammes of absolute (100 per cent.) hydrochloric acid needed to combine with 100 Gm. of calcium carbonate?
2. How many grammes of 31.9 per cent. hydrochloric acid needed to combine with 100 Gm. of calcium carbonate?
3. How many grammes of calcium chloride will be made from 100 Gm. of calcium carbonate?
4. How many grammes of 31.9 per cent. hydrochloric acid needed to combine with 10 Gm. calcium carbonate?

Compare these figures with the recipe given above.

Now let us calculate the manufacture of calcium carbonate. Work out molecular weights of calcium chloride, calcium carbonate, and monohydrated sodium carbonate, and place these molecular weights under the equation (B) given above. Then solve the following problems:

1. How many grammes of calcium carbonate can be made from 111 Gm. of calcium chloride?
2. How many grammes of monohydrated sodium carbonate needed to combine 111 Gm. of calcium chloride?
3. How many grammes of calcium carbonate can be made from 11.1 Gm. of calcium chloride?
4. How many grammes of crystalline sodium carbonate needed to combine 11.1 Gm. of calcium chloride?

Compare these figures with that of the recipe given above.

Remarks on Process.—The solution of the marble and the precipitation of the chalk are explained fully enough in recipe.

Decant supernatant liquid. Supernatant liquid is the clear liquid resting above precipitate. Decant it by gently tilting beaker, being careful to keep precipitate resting quietly at bottom of beaker. Use guiding rod if desired. (See p. 129.)

Wash precipitate to remove all soluble salts, be they either calcium chloride or sodium carbonate. If the former is present, the silver nitrate will give a white, curdy precipitate; if sodium carbonate is there, the calcium chloride will give a white precipitate. If both are washed out and only water passes through the precipitated chalk, it will, of course, produce no precipitate with either reagent.

Dry the precipitate as you did the granulated salts (see p. 972), only, if desired, more heat can be used than with them—even the heat of a radiator or a drying oven.

MAKE EFFERVESCENT SODIUM PHOSPHATE

Exsiccated sodium phosphate	5 Gm.
Sodium bicarbonate	11.9 Gm.
Tartaric acid, dried and powdered	6.3 Gm.
Citric acid, in effervescent crystals	4.1 Gm.

Powder the Citric Acid and mix it intimately with the Exsiccated Sodium Phosphate and Tartaric Acid, then thoroughly incorporate the Sodium Bicarbonate.

Place the mixed powders on a plate of glass or in a suitable dish, in an oven heated to between 93° and 104°C.

When the mixture has acquired a moist consistence, by the aid of careful manipulation with a wooden spatula, rub it through a No. 6 tinned-iron sieve, and dry the granules at a temperature not exceeding 54°C. Keep the product in well-stoppered bottles.

Chemical Explanation.—In the recipe just given the exsiccated sodium phosphate is mixed with sodium bicarbonate, tartaric and citric acids and the mixture is then warmed until it becomes doughy, when it is granulated by rubbing through a coarse sieve. Heat produces a doughy mass because of the presence of water of crystallization in the citric acid, $H_3C_6H_5O_7+H_2O$, the amount being sufficient to soften the mixture without very serious loss of carbon dioxide.

The dry granules contain, beside sodium phosphate, particles of sodium bicarbonate, tartaric acid and citric acid, and perhaps a small amount of the sodium salt of the two acids just mentioned. It is designed however, to have the two acids and the bicarbonate rest side by side in uncombined form. As soon as the dried granules are thrown into water the three chemicals combine with violent effervescence (liberation of carbon dioxide) as shown in the following equations:

Sodium bicarbonate	plus	Citric acid	give	Sodium citrate	plus	Carbon dioxide	plus	water
$NaHCO_3$	+	$H_3C_6H_5O_7$	=		+		+	
Sodium bicarbonate	plus	Tartaric acid	give	Sodium tartrate	plus	Carbon dioxide	plus	water
$NaHCO_3$	+	$H_2C_4H_4O_6$	=		+		+	

Complete these equations.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Thoroughly mix the four chemicals, sodium phosphate and bicarbonate, tartaric and citric acids, by trituration in a mortar.

The sodium phosphate must be exsiccated, since the crystalline salt contains 60 per cent. of water, which would cause undue effervescence of the mass during mixing and granulating. Dried tartaric acid must likewise be used.

Soften the mixed powders by warming in an oven between 93° and 104°C. as mentioned above, the water of crystallization in the citric acid is just sufficient to cause an interaction between the chemicals with a reduction of the softening point of the mixture.

Push moist mass through clean coarse sieve, letting granules fall on paper placed beneath.

Dry granules by placing paper on radiator and put into dry bottle without great delay.

MAKE SYRUP OF LIME (U.S.P. VIII)

Recipe.—	**Lime**	**6.5 Gm.**
	Sugar	**35.0 Gm.**
	Water, a sufficient quantity,	
	To make...	**100 mils**

Slake the lime by the addition of 4 mils of water with the aid of heat, then mix it and the sugar thoroughly in a mortar, so as to form a homogeneous powder; add the mixture to 50 mils of boiling water, contained in a bright copper or tinned-iron vessel, and boil for five minutes, constantly stirring. Dilute the liquid with sufficient water to make it measure 95 mils, and filter through white paper, closely covering the funnel during filtration. Then add through the filter enough water to make the product measure 100 mils, and mix thoroughly. Keep syrup in well-stoppered bottles.

Chemical Explanation.—Lime is only sparingly soluble in water, lime water, the saturated solution, containing only one-sixth of 1 per cent. of lime.

On the other hand, lime is quite soluble in water if first combined with sugar; for, in this case, a chemical combination takes place between the lime and the sugar. Such combination is called calcium saccharate, although this is scarcely correct, inasmuch as sugar contains no acid, but is an aldehyde or ketone alcohol, and the calcium compound is, therefore, similar to sodium alcoholate (see p. 591) and sodium carbolate (see p. 687).

Since the chemistry of this calcium saccharate is rather vague, no attempt will be made to work out the equation of manufacture.

Remarks on Process.—*The bright copper vessel* can be a well-scoured copper water-bath. Porcelain dish not advisable, since the lime will attack the glazing.

Filter diluted liquid through white paper. The filtrate should be perfectly transparent, and must be returned through filter-paper until it is clear.

Strain through piece of muslin previously well wetted with water.

In evaporating filtrate do not let it get too concentrated, for then there results a sticky mass, which is difficult to remove.

In boiling the solids with water, be sure to add extra water to make up for loss of water through evaporation. If this is not heated, a sticky and difficultly soluble mass results.

MAKE SOLUTION OF ZINC CHLORIDE

Recipe.—	Zinc, granulated	12.0 Gm.
	Hydrochloric acid	42.0 Gm.
	Nitric acid	0.6 Gm.
	Precipitated zinc carbonate	0.6 Gm.
	Distilled water, a sufficient quantity,	
	To make about...	50 Gm.

To the zinc, contained in a glass or porcelain vessel, add 8 mils of distilled water; then gradually add the hydrochloric acid, and digest until reaction ceases and the acid is saturated. Pour off the solution, add the nitric acid, and heat the solution at a temperature not exceeding 115°C., until a portion, if removed and cooled, solidifies. Allow it to cool, and dissolve the solidified mass in a sufficient quantity of distilled water to make the product weigh 50 Gm. Then add the precipitated zinc carbonate, agitate the mixture occasionally during twenty-four hours, and set it aside until it has become clear by subsidence. Finally, separate the clear solution by decantation or by means of a siphon.

Chemical Explanation.—Zinc chloride is made by treating zinc with hydrochloric acid, the reaction being as follows:

Zinc plus Hydrochloric acid give Hydrogen plus Zinc chloride.

$$Zn \;+\; HCl \;=\; \qquad + $$

Complete this equation.

As this solution is supposed to be made from commercial zinc, and as this *usually* contains iron, the iron chloride produced when such metal is dissolved in hydrochloric acid must be removed from the solution. This is accomplished by adding nitric acid, evaporating the solution, and finally fusing the dry mass. Neither nitric acid nor fusion affects the zinc chloride, while nitric acid and fusion convert the ferric chloride into insoluble ferric oxide, and when the fused mass is treated with water, the zinc chloride dissolves, leaving the ferric oxide as an insoluble residue.

The solution is too caustic to be filtered through paper, so the ferric oxide is removed by sedimentation, precipitated zinc carbonate being added to aid in the clarification.

Calculations.—Figure out the molecular weights of hydrochloric acid and of zinc chloride, and give the atomic weight of zinc, and with these figures work out the following examples:

1. How many grammes of zinc and absolute (100 per cent.) hydrochloric acid needed to make 136 Gm. zinc chloride?
2. How many grammes of 31.9 per cent. hydrochloric acid needed to make 136 Gm. zinc chloride?
3. How much zinc chloride in 50 Gm. solution of zinc chloride, U.S.P., if this solution contains 50 per cent. of the salt?
4. How much zinc and 32 per cent. hydrochloric acid needed to make 25 Gm. of zinc chloride?
5. Then how much zinc and 32 per cent. hydrochloric acid needed to make 50 Gm. solution of zinc chloride, U.S.P.?

Compare with quantities given in above recipe.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Place zinc in Erlenmeyer flask, **and add thereto the water and the acid.**

Digest mixture **by letting stand several hours in a warm place—say, on**

a radiator or at back of stove. Note evolution of hydrogen gas as the zinc dissolves in the hydrochloric acid.

Pour off solution (instead of filtering) into a beaker or 8-ounce wide-mouthed bottle, and evaporate to dryness in small evaporating dish on sand-bath. If the dish is not large enough to hold all the solution at one time, add part at first, and when this has evaporated, add the rest. When mass is dry,

Fuse cautiously, so as to not exceed the pharmacopœial temperature, else the zinc chloride loses chlorine and decomposes. A thermometer is not necessary, however, if the mass is cautiously fused over a Bunsen burner.

Dissolve fused mass in about 25 mils distilled water, and transfer to tared Erlenmeyer flask. Wash out dish with 5 to 10 mils water, and use this water for bringing the weight of the solution in Erlenmeyer up to 50 Gm.

Separate clear solution by decantation. A syphon is suitable only when a large quantity is made.

MAKE SOLUTION OF TERSULPHATE OF IRON

Recipe.—**Ferrous sulphate,** in clear crystals	**62.5 Gm.**
Sulphuric acid	**12.0 Gm.**
Nitric acid,	
Distilled water, each, a sufficient quantity,	
To make	**125 Gm.**

Add the sulphuric acid to about 30 mils of distilled water in a capacious porcelain dish, heat the mixture to nearly 100°C., then add 7 Gm. of nitric acid, and mix well. Divide the ferrous sulphate, coarsely powdered, into four equal portions, and add these portions, one at a time, to the hot liquid, stirring after each addition until effervescence ceases. When all the ferrous sulphate is dissolved, if the solution has acquired a black color, add nitric acid, a few drops at a time, heating and stirring until it no longer causes red fumes to be evolved, and the solution assumes a clear, reddish-brown color; then boil the liquid until it is free from nitric acid. Lastly, add enough distilled water to make the product weigh 125 Gm. Filter if necessary.

Chemical Explanation.—This solution is prepared by the oxidation of green ferrous sulphate, $FeSO_4$, to red-brown ferric sulphate, $Fe_2(SO_4)_3$, through oxidizing action of nitric acid in the presence of sulphuric acid. The need of this extra sulphuric acid is shown in comparison of the formulas of ferrous sulphate and ferric sulphate respectively:

Ferrous sulphate.	*Ferric sulphate.*
$FeSO_4$	$Fe_2(SO_4)_3$

$2FeSO_4$ or $Fe_2(SO_4)_2$ in changing to $Fe_2(SO_4)_3$,

requiring an extra SO_4 group.

The oxidizing action of nitric acid is fully explained on p. 399, and there it is shown that every two molecules of nitric acid give three atoms of oxygen in oxidations. With these hints construct the equation representing the reaction, viz.:

Ferrous sulphate plus sulphuric acid plus nitric acid equals ferric sulphate plus nitrogen dioxide plus water.

Note that the red fumes given off during the reaction are not N_2O_2, but are N_2O_4, which is formed the moment the colorless gas N_2O_2, comes in contact with air, viz.:

$$N_2O_2 + O_2 = N_2O_4.$$

Calculations.—Figure out molecular weight of crystallized ferrous sulphate ($FeSO_4 7H_2O$), sulphuric acid, nitric acid, and ferric sulphate, and with these figures work out the following examples:

1. How many grammes crystalline ferrous sulphate, 100 per cent. sulphuric acid, and 100 per cent. nitric acid needed to make 1200 Gm. of ferric sulphate?
2. How many grammes 94 per cent. sulphuric acid needed to make 1200 Gm. of ferric sulphate?
3. How many grammes 68 per cent. nitric acid needed to make 1200 Gm. of ferric sulphate?
4. How many grammes of ferric sulphate are contained in 125 Gm. of solution of ferric sulphate, U.S.P., which is about 36 per cent. $Fe_2(SO_4)_3$?
5. How many grammes of crystalline ferrous sulphate, 94 per cent. sulphuric acid, and 68 per cent. nitric acid needed to make 45 Gm. ferric sulphate?
6. Then how many grammes of these three constituents needed to make 125 Gm. of solution of ferric sulphate, U.S.P.?

Compare with quantities in official recipe.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Mix sulphuric acid and water in tared pint evaporating dish, carefully pouring acid into water and not the reverse.

Add the ferrous sulphate gradually, letting reaction end before adding another of the four portions.

Add the nitric acid fairly generously. If you get an excess, it can be driven off by heating mixture. Do not add too much, however, as it will be wasteful of the acid, and will also require long heating to drive it all off.

If the liquid is black, it means an insufficiency of nitric acid. Add some, and the red tint will come, accompanied by evolution of N_2O_4 fumes.

Boil until free from nitrous odor, that is, the choking odor of nitric acid and of N_2O_4. Experience will readily teach you the odor.

Add water to make product weigh 125 *Gm.* To do this easily, be sure to tare the dish before starting.

MAKE SOLUTION OF FERRIC CITRATE

Recipe.—	Solution of ferric sulphate	**42.0 Gm.**
	Citric acid	**15.0 Gm.**
	Ammonia water	**44.0 mils**
	Water, a sufficient quantity,	
	To make...	**50 Gm.**

Mix the ammonia water with 150 mils of cold water, and the solution of ferric sulphate with 500 mils of cold water. Add the latter solution slowly to the diluted ammonia water, with constant stirring. Pour the mixture on a wet muslin strainer, and allow the liquid to run off and the precipitate to drain. Then remove the moist mass from the strainer, mix it well with 300 mils of cold water, again pour it on the strainer, and let it drain. Repeat this washing with several successive portions of cold water in the same manner, until the washings cease to produce more than a slight cloudiness with barium chloride test-solution. Then allow the precipitate to drain completely, transfer it to a porcelain capsule, add the citric acid, and heat the mixture, on a water-bath, to 60°C. stirring constantly until the precipitate is dissolved. Lastly, filter the liquid, and evaporate it, at the above-mentioned temperature, until it weighs 50 Gm.

Chemical Explanation.—This is substantially the recipe given in the present edition of the National Formulary. The first stage of the process of the precipitation of ferric hydroxide from the solution of ferric sulphate is by the following reaction:

Ferric		Ammonium		Ferric		Ammonium
sulphate	plus	hydroxide	give	hydroxide	plus	sulphate.
$Fe_2(SO_4)_3$	$+$	NH_4OH	$=$		$+$	

Complete this equation.

The ferric hydroxide is freed from ammonium sulphate by washing with water, and is then treated with citric acid, which converts the moist ferric hydroxide into solution of ferric citrate, viz.:

Ferric		Citric		Ferric		
hydroxide	plus	acid	give	citrate	plus	Water.
$Fe_2(OH)_6$	$+$	$H_3C_6H_5O_7$	$=$		$+$	

Complete this equation.

Calculations.—As the ferric citrate is a rather variable product, containing excess of citric acid, attempts to figure out proportions by molecular weights are of no avail.

Remarks on Process.—*Place the diluted ammonia in a quart fruit-jar,* and pour therein the solution of ferric sulphate diluted with 500 mils of water. Note the red-brown ferric hydroxide precipitates as a magma (p. 145). Note that this is an antidote for arsenic (p. 515).

Pour mixture on wet muslin strainer, spread upon a straining rack. Unless the strainer is of fine mesh, the precipitate will run through. If too fine, the draining will be a slow operation. In large operations it is well to have three strainers on racks placed one above the other, and the magma is poured into the upper one. Most of the precipitate which passes through the upper strainer is caught by the middle one, and whatever does get through the middle one is caught by the lowest one. In laboratory work the laying of a 6-inch filter-paper flat on the strainer holds the magma excellently. Collect drippings in pint evaporating dish and return to strainer whatever passes through containing magma. The drippings should be clear and colorless.

Remove mass from strainer while washing. This part of the pharmacopœial process is a smeary process in the laboratory operation. In large operations, where the strainer is fine duck attached to the frame, the magma can be easily scraped from the strainer with a big spoon; but in the laboratory process it is usually better to wash magma while on the strainer, and that either with a syphon (p. 130) or by continuous washing with inverted flask (p. 128). In washing thus, be careful not to disturb the magma so that it will run through strainer.

Wash until drippings give no precipitate with barium chloride. That is, until free from ammonium sulphate.

Transfer magma to porcelain capsule—that is, to evaporating dish, by scraping off the strainer with spatula or with a spoon.

Do not heat magma and citric acid above 60°C.—that is, even the full heat of a water-bath is apt to decompose the citrate.

Filter solution and evaporate in tared pint evaporating dish.

MAKE SCALED FERRIC CITRATE (U.S.P. VIII)

Recipe.—**Solution of ferric citrate**	**25 Gm.**

Evaporate the solution on a water-bath, at a temperature not exceeding 60°C., to the consistence of syrup, and spread it on plates of glass, so that, when dry, the salt may be obtained in scales.

Keep the product in well-stoppered bottles, protected from light.

Remarks on Process.—Solution of ferric citrate (U.S.P. 1890) is about 50 per cent. solid ferric citrate, and the 25 Gm. should, therefore, yield about 12½ Gm. of the scaled salt.

Evaporate at low temperature (60°C.) to avoid decomposition.

Spread syrupy liquid on sheet of glass or on a pill-tile. Be sure to spread thinly, using glass rod in getting layer smooth. If poured on thickly, opaque scales result.

Leave liquid on plates until perfectly dry, using no heat whatever. Artificial heat—even a radiator—causes blisters.

If properly prepared, the dry salt will scale off the pill-tile without scraping, and that in the form of beautiful shining garnet scales.

Iron and ammonium citrate U.S.P. is made similarly, the only difference being the addition of ammonia water to the solution of ferric citrate before scaling.

MAKE MASS OF FERROUS CARBONATE

Recipe.—**Ferrous sulphate,** in clear crystals	**20.0 Gm.**
Monohydrated sodium carbonate	**9.2 Gm.**
Clarified honey	**7.6 Gm.**
Sugar, in coarse powder	**5.0 Gm.**
Syrup,	
Distilled water, each, a sufficient quantity,	
To make	**20 Gm.**

Dissolve the ferrous sulphate and the monohydrated sodium carbonate, each separately, in 40 mils of boiling distilled water, and, having added 4 mils of syrup to the solution of the iron salt, filter both solutions, and allow them to become cold. Introduce the solution of monohydrated sodium carbonate into a bottle having a capacity of about 100 mils, and gradually add the solution of the iron salt, rotating the bottle constantly or frequently, until carbonic acid gas no longer escapes. Add a sufficient quantity of distilled water to fill the bottle; then cork it and set it aside, so that the ferrous carbonate may subside. Pour off the supernatant liquid, and, having mixed syrup and distilled water in the proportion of one volume of syrup to nineteen volumes of distilled water, wash the precipitate with the mixture by decantation until the washings no longer have a saline taste. Drain the precipitate on a muslin strainer, and express as much of the water as possible. Lastly, mix the precipitate at once with the honey and sugar, and, by means of a water-bath, evaporate the mixture in a tared dish, with constant stirring, until it is reduced to 20 Gm.

Chemical Explanation.—When solutions of ferrous sulphate and sodium carbonate are mixed, ferrous carbonate precipitates in the form of a slate-gray solid, viz.:

Ferrous sulphate	plus	Sodium carbonate	give	Ferrous carbonate	plus	Sodium sulphate.
$FeSO_4 7H_2O$	+	$Na_2CO_3H_2O$	=		+	

Complete this equation.

Ferrous carbonate is a very unstable substance, being converted by action of the atmosphere into red-brown subcarbonate of iron—a mixture of ferrous carbonate and ferric oxide. This change will be noted during the manufacture of the mass in all portions not protected from atmospheric action.

The presence of saccharine matter retards this change, and this explains why the precipitate is washed with water containing syrup, and why the finished product is preserved with sugar and honey. The precipitation is directed to be performed in a flask which is to be kept closed as much as possible, in order to lessen atmospheric action. It will be seen above that the other product of the reaction is sodium sulphate, and the precipitate is to be washed free from this with water and syrup.

Calculations.—The pharmacopœia directs that the mass contains at least 35 per cent. of ferrous carbonate and how near this is to the theoretical amount, the following calculations will show.

Estimate molecular weight of crystalline ferrous sulphate ($FeSO_4 7H_2O$), of monohydrated sodium carbonate ($Na_2CO_3H_2O$), and of ferrous carbonate, and from the figures work out the following examples:

1. How many grammes monohydrated sodium carbonate will combine with 278 Gm. crystalline ferrous sulphate?
2. How many grammes ferrous carbonate can be made from 278 Gm. crystalline ferrous sulphate?
3. How many grammes of monohydrated sodium carbonate will combine with 20 Gm. of crystalline ferrous sulphate?
4. How many grammes ferrous carbonate can be made from 20 Gm. crystalline ferrous sulphate?
5. How many grammes of ferrous carbonate should there be in 20 Gm. mass of ferrous carbonate?
6. Then what percentage of ferrous carbonate should there be in mass of ferrous carbonate?

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Dissolve the ferrous sulphate in water in one beaker.

Dissolve the sodium carbonate in water in the other beaker.

Filter the sodium carbonate solution into Erlenmeyer flask, to which a cork should have been previously fitted.

Filter the ferrous sulphate solution into the beaker just emptied after it has been washed and dried.

Cork the Erlenmeyer flask as soon as convenient, after adding the ferrous sulphate solution, but be careful not to allow enough carbon dioxide to collect to explode the flask. Open flask from time to time to let collected gas escape, but only for a moment each time. Be sure to fill flask with water.

Wash precipitate on same kind of strainer used for ferric hydroxide in making ferric citrate.

Evaporate mixture in tared dish, that is, in an evaporating dish, the weight of which should first be ascertained.

MAKE SYRUP OF FERROUS IODIDE

Recipe.—**Iron,** in the form of fine, bright wire, and cut into small pieces	**1.25 Gm.**
Iodine	**4.15 Gm.**
Diluted hypophosphorous acid	**2.00 mils**
Sugar	**60.00 Gm.**
Distilled water, a sufficient quantity,	
To make	**100 Gm.**

Introduce the iron into a flask of thin glass, having a capacity of about 50 mils, add to it 15 mils of distilled water, and afterward the iodine. Shake the mixture occasionally, checking the reaction, if necessary, by the affusion of cold water, and, when the solution has acquired a greenish color and has lost the odor of iodine, heat it to boiling and add at once 5 Gm. of the sugar; when this has dissolved, filter the solution into the remainder of the sugar contained in a porcelain dish. Rinse the flask and iron wire with 12½ mils of distilled water and pass the washings through the filter into the sugar. Stir the mixture with a porcelain or wooden spatula, heating the liquid on a water-bath until complete solution is effected, and, having passed the syrup through a clean muslin strainer into a tared bottle, add the diluted hypophosphorous acid and sufficient distilled water to make the product weigh 100 Gm.

Chemical Explanation.—Ferrous iodide is made by the direct combination of the two elements, iron and iodine, viz.:

Iron plus Iodine equal Ferrous iodide.
$Fe + I =$

Complete this equation.

Calculations.—Figure out the atomic and molecular weights involved in the above equation, and then solve the following problems:

1. How many grammes iron needed to make 310 Gm. ferrous iodide?
2. How many grammes iron needed to make 5 Gm. ferrous iodide?
3. How many grammes iodine needed to make 310 Gm. ferrous iodide?
4. How many grammes iodine needed to make 5 Gm. ferrous iodide?
5. How many grammes ferrous iodide in 100 Gm. syrup ferrous iodide (5 per cent.)?
6. Then how many grammes of iron and iodine needed to make 100 Gm. syrup of ferrous iodide?
7. Compare these figures with amounts given in official recipe. The slight excess of iron is used to insure complete combination of the iodine.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

The iron used had best be that form known in commerce as "card teeth."

Place iron either in Erlenmeyer flask or in large test-tube.

After adding the iodine it is well to plug flask with a pledget of cotton to prevent loss of iodine by volatilization.

If reaction is slow on starting, very gentle heat may be employed. *Very gentle* is meant, as anything more will cause loss by volatilization.

If reaction becomes violent, check it by holding flask under running water.

Have the sugar in tared pint evaporating dish, as finished product must be brought up to a certain weight.

Keep in completely filled bottles, else it turns brown with decomposition of the ferrous iodide. One-ounce bottles well corked are indicated.

MAKE SOLUTION OF LEAD SUBACETATE

Recipe.—	**Lead acetate**	**18 Gm.**
	Lead oxide	**11 Gm.**
	Distilled water, a sufficient quantity,	
	To make...	**100 Gm.**

To the finely powdered lead oxide contained in a porcelain dish, of about half-liter capacity, add slowly and in portions, with constant stirring, the lead acetate which has been previously dissolved in 70 mils of boiling distilled water, and boil the liquid for half an hour, with occasional stirring. Finally, when cool, filter the solution, and add sufficient distilled water, which has been previously boiled and cooled, to make the finished product weigh 100 Gm. Keep the solution in well-stoppered bottles.

Chemical Explanation.—As explained on p. 513, a "sub" salt is a basic salt—that is, a combination of a salt of a metal with the oxide of the same metal.

In the preparation under consideration the "sub" salt is made by direct combination of the salt and the oxide, lead acetate and lead oxide being boiled together with the formation of lead subacetate, as shown in the following equation:

Lead acetate	plus	Lead oxide	give	Lead subacetate	plus	Water
$Pb(C_2H_3O_2)_2 3H_2O$	$+$	PbO	$=$	$Pb_2O(C_2H_3O_2)_2$	$+$	$3H_2O$.
(Soluble.)		(Insoluble.)		(Soluble.)		

Calculations.—Figure out molecular weights of the three lead preparations given above, and from these figures work out the following examples:

1. How many grammes lead acetate needed to make 548 Gm. lead subacetate?
2. How many grammes lead acetate needed to make 25 Gm. lead subacetate?
3. How many grammes lead oxide needed to make 548 Gm. lead subacetate?
4. How many grammes lead oxide needed to make 25 Gm. lead subacetate?
5. How many grammes lead subacetate in 100 Gm. solution of lead subacetate which is approximately 25 per cent. subacetate?
6. Then how many grammes of lead subacetate and lead oxide needed to make 100 Gm. solution of lead subacetate?

Compare with amounts directed in official recipe.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Dissolve lead acetate in pint flask.

Pass the lead oxide through a No. 80 *sieve* before weighing, then put into tared pint evaporating dish.

Boil mixture a half-hour, during which time a large amount of the insoluble lead oxide passes into the soluble lead subacetate.

All the lead oxide will not dissolve, however, and that is the reason an excess over the theoretic amount is directed in official recipe.

Add hot water to make up the loss of evaporation, otherwise the mixture will evaporate to dryness during the half-hour's boiling.

Make finished product weigh 100 *Gm.* by adding enough *freshly boiled* water. Even distilled water contains carbon dioxide if allowed to stand, and this carbon dioxide will precipitate the lead as lead carbonate; so boil the water to drive off the dissolved carbon dioxide before using it as a diluent.

Filter in closely covered funnel and keep in well-stoppered bottles to prevent atmospheric action. The air contains carbon dioxide, and this precipitates the lead, as mentioned above.

MAKE LEAD PLASTER, U.S.P.

Recipe.—	**Lead oxide**	**16 Gm.**
	Olive oil	**30 Gm.**
	Water, a sufficient quantity.	

Mix the lead oxide, previously passed through a No. 80 sieve, intimately with about one-half of the olive oil, by trituration, and add the mixture to the remainder of the oil contained in a bright copper boiler of a capacity equal to at least four times the bulk of the ingredients. The add 5 mils of boiling water, and boil the whole together, over a fire, constantly stirring with a wooden spatula, until a small portion, when dropped into cold water, is found to be pliable and tenacious. From time to time add a little water to replace that lost by evaporation. When the contents of the boiler have acquired a whitish color and are perfectly homogeneous, transfer them to a vessel containing warm water, and as soon as the mass has sufficiently cooled, knead it well with the water so as to remove the glycerin, renewing the water from time to time, as long as it may be necessary. Finally, divide the mass into rolls of suitable size.

Chemical Explanation.—As learned on p. 665 when an oil—which is the combination of glycerin with oleic acid and other acids—is treated with the hydroxide of a metal, glycerin is set free and a metallic oleate is formed. Thus, if an oil is treated with soda ($NaOH$), sodium oleate or hard soap is formed; if the same oil is treated with potassa (KOH), potassium oleate or soft soap is obtained.

Therefore, when olive oil is boiled with lead oxide in the presence of water (thus forming lead hydroxide, viz., $PbO+H_2O=Pb(OH)_2$), lead oleate is produced by the following equation:

Olive oil
(Olein)
(Glyceryl oleate) plus lead hydroxide give lead plaster plus glycerin

$$C_3H_5(C_{18}H_{33}O_2)_3 \quad + \quad Pb(OH)_2 \quad = Pb(C_{18}H_{33}O_2)_2 + C_3H_5(OH)_3.$$

Complete this equation.

The result of the reaction is a viscid mass consisting chiefly of lead oleate, and called lead plaster, and by kneading this lead plaster with water the glycerin is removed.

As the olive oil contains traces of glyceryl palmitate and glyceryl stearate, the finished plaster contains some lead palmitate and lead stearate; hence it is not a definite chemical.

Calculations.—Since we are not dealing with definite chemicals, the molecular proportions of this reaction cannot be easily worked out; hence they are omitted.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student.

Triturate the sifted lead oxide in mortar with about half the oil, rubbing it with small portions of the oil at a time, thus using the oil to wash the oxide into the rest of the oil in tn the evaporating dish. Be sure to get all the oxide out of the mortar into the dish.

The *plaster should be cooked in a copper boiler*, since the lead is apt to attack glass or porcelain, dissolving off some. For the small amount we are making, however, the pint evaporating dish can be used.

Boil mixture in dish over Bunsen burner flame on wire gauze, stirring with wooden paddle. Both glass rod and steel spatula are tabooed—the first for fear the lead might attack it; the steel spatula lest the oleic acid attack it.

Replace water lost by evaporation, and that only cautiously, adding boiling hot water. The temperature of the boiling plaster mass is considerably above 100°C., and if cold water is added, steam will be developed with explosive suddenness, sputtering the hot plaster mass in all directions, and rendering the operator liable to severe burns.

The *mass is finished* when a drop solidifies in water.

After kneading out the glycerin from the finished mass the glycerin may be recovered from the water solution—from the wash-water—by evaporating off the water at very low heat.

Use hydrant water for the kneading.

MAKE RESIN PLASTER

Recipe.—**Resin,** in fine powder	**3.5 Gm.**
Lead plaster	**20.0 Gm.**
Yellow wax	**1.5 Gm.**

Melt the lead plaster and yellow wax together with a gentle heat; then add the resin, and, when it is melted, mix the mass thoroughly.

As this mixture is a galenic preparation, there will be no molecular calculations.

Remarks on Process.—The recipe just given is similar to but not identical with that given in the present edition of the pharmacopœia. The two recipes should be carefully compared by the student. Melt the mixture in pint evaporating dish and strain into a tin or tinned-iron dipper.

SPREAD A RESIN PLASTER 4 x 6

The spreading of plasters has become a lost art, but every pharmacist should have sufficient practice to know how to spread one in an emergency.

A plaster is usually spread either on leather (the commercial variety called split skin) or on muslin. This, for convenience, we will call the foundation.

For laboratory practice a sheet of paper can be used. Let the material on which the plaster is spread be sufficiently large to permit a margin of at least an inch all around after the plaster is spread.

The leather, cloth, or paper is carefully stretched over a perfectly level board (the clean counter will do, if it can be pierced with pins), and fastened down at margins with the brass or nickle-headed tacks known commercially as thumb tacks. With paper, this stretching is unnecessary.

Strips of fairly heavy linen paper are cut with an exact, sharp margin, the strips being about two inches wide and eight inches long. The strips are placed on the stretched plaster paper in such a way as to form an exactly even frame inclosing a space the size of the plaster directed to be spread; in this case, four by six inches. The strips are fastened at each corner by thumb tacks, and when made secure the tacks originally used for stretching the leather—if leather is used—may be removed.

This done, the plaster mass in tin dipper is cautiously fused, and when melted, small portions of the molten mass are taken out with a spatula and smeared between strips and foundation in very thin layer, in order to fasten the strips to the foundation. Then the spatula is carefully cleaned by passing through a flame of Bunsen burner and wiping off on paper. The foundation should be placed with the length running with the length of the counter, and on this, at narrow end to the left, should be poured the fused mass, so as to cover about one-third the length of the plaster. Then, without loss of time, the spatula should be warmed by passing through the flame, and being held in the right hand with blade slightly inclined forward, but perfectly level, about one-quarter to one-half inch above the whole width of plaster, the spatula should be moved rapidly and firmly to the right, pushing before it the still molten plaster mass and leaving behind a smooth, shining spread plaster.

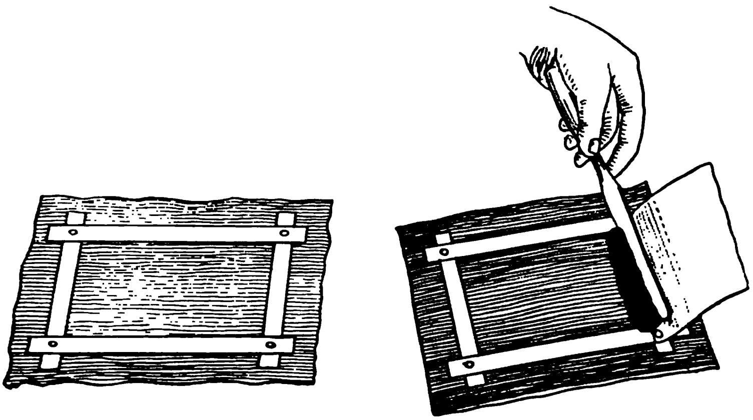
Fig. 266. Fig. 267.

Figs. 266 and 267.—Spreading a plaster.

Remarks on Process.—The *spatula* should be at least eight inches long, and should not be sufficiently heated to decompose the plaster mass.

The *plaster mass* should be cautiously fused—not too hot to decompose or to run through the foundation, and yet limpid enough to remain fused until the plaster is entirely spread.

Running the spatula over the fused mass is the delicate part of the process. It must be done as quickly as possible lest the mass solidifies before the process is complete. The spatula must be held perfectly steady else the plaster will be uneven.

In fastening the foundation to the counter place it an inch or so from the edge of the counter, thus leaving a rest for the hand holding the spatula as it passes over the mass.

Remove the strips from the plaster by taking out thumb tacks and pull-[illegible] off. If the mass is brittle, passing a warm spatula over the strips sometimes aids in loosening them, though this must be done with caution, lest the plaster itself becomes smeary. The strips removed, a clearly defined plaster should remain, the excess of the mass having been removed with the strips.

The *excess of mass on strips* can be scraped off the strips with warm spatula and left for use another time.

There is littlle use to attempt to redeem a poorly spread plaster by "reironing;" that is, by trying to smooth it with a warm spatula. The best thing to do is to scrape the mass from the foundation with warm spatula and try over again.

Other plans for plaster spreading by hand have been followed with more or less success. Thus, for the paper strips, strips of pasteboard one-quarter inch thick have been used, and the entire space within the frame filled with the molten mass, the excess being scraped off with the warm spatula. Others cut the frame from an entire sheet of paper.

For *machine spreading of plasters*, see p. 340.

MAKE YELLOW MERCURIC OXIDE

Recipe.—**Corrosive mercuric chloride**...................... 10 Gm.
Sodium hydroxide............................. 4 Gm.
Distilled water, a sufficient quantity.

Dissolve the corrosive mercuric chloride in 100 mils of warm distilled water, and filter the solution. Dissolve the sodium hydroxide (which should contain at least 90 per cent. of pure anhydrous sodium hydroxide) in 100 mils of cold distilled water, and into this solution pour gradually, and with constant stirring, the solution of corrosive mercuric chloride. Allow the mixture to stand for an hour at a temperature of about 30°C. stirring frequently. Then decant the supernatant, clear liquid from the precipitate, and wash the latter repeatedly by the addition and decantation of portions of distilled water, using 100 mils of water each time. Collect the precipitate on a strainer, and continue the washing with warm distilled water until a small portion of the washings, when poured on a little mercuric chloride test-solution, no longer produces a yellowish turbidity at the line of contact of the two liquids. Then allow the precipitate to drain, and dry it between sheets of bibulous paper, in a dark place, at a temperature not exceeding 30°C., and keep it in well-stoppered bottles, protected from light.

Chemical Explanation.—When solutions of mercuric chloride and of sodium hydroxide are combined, yellow mercuric oxide is precipitated by the following reaction:

Mercuric chloride	plus	Sodium hydroxide	give	Mercuric oxide	plus	Water	plus	Sodium chloride.
$HgCl_2$	+	NaOH	=		+		+	

Complete this equation.

Calculations.—Work out molecular weights of mercuric chloride, sodium hydroxide, and mercuric oxide (HgO). From these figures work out the following examples:

1. How many grammes of mercuric oxide can be made from 271 gm. mercuric chloride?

2. How many grammes of mercuric oxide can be made from 10 Gm. mercuric chloride?

3. How many grammes of sodium hydroxide (100 per cent.) will combine with 271 Gm. mercuric chloride?

4. How many grammes of sodium hydroxide (85 per cent.) will combine with 271 Gm. mercuric chloride?

5. How many grammes of sodium hydroxide (85 per cent.) will combine with 10 Gm. mercuric chloride?

Compare with figures given above, and weigh your finished mercuric oxide to see if it agrees with the theoretic yield.

In the recipe given above, which was that of the last pharmacopœia the excess of sodium hydroxide is to insure complete precipitation of the mercury, the surplus soda being washed out of the precipitate with water.

Remarks on Process.—*Dissolved the mercuric chloride* in Erlenmeyer flask and filter into an 8-ounce wide-mouthed bottle.

Dissolve the sodium hydroxide in pint flask, and into this pour the mercuric chloride solution.

Wash the precipitate by decantation as far as possible, and finally *throw precipitate on plain filter*, instead of on strainer, as the U.S.P. directs. Were we making the pharmacopœial quantity (ten times our present amount), a strainer would be indicated, but with the small amount we have, a plain filter will suffice.

Wash until washings no longer respond with mercuric chloride test-solution—that is, until free from sodium hydroxide. If the hydroxide is present in water, a yellow precipitate (HgO) is produced with mercuric chloride solution.

In testing for sodium hydroxide place about one inch of the mercuric solution in test-tube and pour thereon very gently, along tilted test-tube, the washings, so as to permit the washings to float on surface of the mercuric chloride solution, thus forming two layers; where the two layers join—"the point of contact"—the yellow color appears.

MAKE OINTMENT OF MERCURIC NITRATE

Recipe.—**Mercury**	**7.0 Gm.**
Nitric acid	**17.5 Gm.**
Lard, free from water	**76.0 Gm.**
To make about...	**100 Gm.**

Heat the lard in a capacious glass or porcelain vessel to a temperature of 105°C. then withdraw the heat, and gradually add 7 Gm. of the nitric acid. When the reaction moderates, reapply the heat until effervescence ceases, and allow the mixture to cool to about 40°C. Having dissolved the mercury in the remainder of the nitric acid, using sufficient heat to prevent the solution from crystallizing, add this solution to the lard mixture. When the mass begins to congeal, stir it thoroughly with a wooden spatula until it is of a bright citrine color. Contact with metallic utensils should be avoided.

Chemical Explanation.—In this preparation two distinct reactions occur: In the first place, mercury dissolves in nitric acid to make mercuric nitrate by either of the following equations:

$$Hg + 4HNO_3 = Hg(NO_3)_2 + N_2O_4 + H_2O.$$
$$3Hg + 8HNO_3 = Hg(NO_3)_2 + N_2O_2 + H_2O.$$

Complete these equations.

Then the white lard is converted into the lemon yellow solid elaidin when the nitric acid is added to it.

Elaidin has the same empiric formula as has the olein of the oil. and since the chemistry of the change is complicated (see p. 652), no molecular weight estimation will be made.

Calculations.—As just mentioned, no calculation can be made on the conversion of olein of the lard into elaidin, nor is the amount of nitric acid used in dissolving the mercury in accord with molecular proportions; hence the amount will not be estimated.

Remarks on Process.—The present pharmacopœia directs that the heat of reaction be 45°C. The writer's experience has been that a temperature of at least 100° is essential to a successful reaction. The secret of making a satisfactory preparation is largely the proper control of the temperature as explained below.

Put lard in pint evaporating dish and heat to 105°C. on wire gauze.

A water-bath will not do, as the lard must be heated to 105°C. in order to get reaction started.

Add the nitric acid gradually, not allowing heat to get too intense. If reaction has gone nicely, an orange-colored liquid results; if overheated, the lard turns chocolate brown.

Reapply heat until effervescence ceases. This must be done, cautiously, else the mass will turn dark. It must be heated enough, or else the finished product will "work," frothing out of container.

Dissolve the mercury in nitric acid in Erlenmeyer flask. Better start it before treating the lard with nitric acid.

If mercuric nitrate solution crystallizes, warm it before mixing with the elaidin mixture.

Use glass rod during the elaidin reaction, and employ a wooden paddle for mixing in the mercuric nitrate solution.

MAKE BISMUTH CITRATE

Recipe.—**Bismuth subnitrate**	**10.0 Gm.**
Citric acid	**7.5 Gm.**
Distilled water, a sufficient quantity.	

Mix the bismuth subnitrate and the citric acid with 40 mils of distilled water, and heat on a bath of boiling water, with frequent stirring, until a drop of the mixture yields a clear solution with ammonia water. Then add 500 mils of distilled water, allow the suspended matter to deposit, wash the precipitate, first by decantation, and afterward on a strainer, with distilled water, until the washings are tasteless, and dry the residue at a gentle heat.

Chemical Explanation.—In this preparation the bismuth subnitrate is converted into bismuth citrate by boiling with citric acid, and affords an interesting illustration of the futility of the old terms, "strong acids" and "weak acids." According to that doctrine, nitric acid is a much "stronger" acid than citric acid, and yet in this case merely boiling of the subnitrate with citric acid causes the driving out of the nitric acid. This is made possible by the fact that nitric acid is a volatile substance, while citric acid is fixed; hence the boiling gives the nitric acid the opportunity for volatilizing, and the citric acid at the same time combines with the metal.

The equation of the change is as follows:

$$BiONO_3H_2O \;+\; H_3C_6H_5O_7H_2O \;=\; BiC_6H_5O_7 \;+\; HNO_3 \;+\; H_2O.$$

Complete this equation.

Calculations.—1. How much citric acid will combine with 305 Gm. bismuth subnitrate?

2. How much citric acid will combine with 10 Gm. bismuth subnitrate?

3. How much bismuth citrate can be made from 305 Gm. bismuth subnitrate?

4. How much bismuth citrate can be made from 10 Gm. bismuth subnitrate?

Remarks on Process.—*Boil the subnitrate* and citric acid with water in pint flask.

Boil until drop of mixture gives clear solution with ammonia. Both the subnitrate and the citrate are insoluble in water, but, while the subnitrate will not dissolve in ammonia water, the citrate does. Hence, when all the subnitrate is converted into citrate, the entire insoluble precipitate will dissolve in ammonia water, and as long as a part of the precipitate does not dissolve, it means that there is still some unchanged bismuth subnitrate and the boiling must be continued.

Carry out this ammonia solubility test by dipping glass rod into the mixture in flask, and then carefully immersing same into ammonia water in a test-tube. The milky drops on the rod will be dissolved so soon as it is placed in ammonia if the conversion is complete. A faint turbidity, however, is permissible, since it seems practically impossible to convert the last traces of the subnitrate into the soluble citrate.

Add 500 *mils water* to wash out last traces of nitric and citric acid. In this case, since the pint flask holds but 450 mils, filling the flask with water will be sufficient.

Wash precipitate by decantation, then on strainer, that is, just as you did ferric hydroxide. With the small amount made with the above quantities, collecting and washing on plain filter (6-inch paper) will suffice.

Dry residue at gentle heat—say, on top of radiator.

MAKE BISMUTH AND AMMONIUM CITRATE

Recipe.—**Bismuth citrate.............................. 10 Gm.**
Ammonia water,
Distilled water, each, a sufficient quantity.

Mix the bismuth citrate with 20 mils of distilled water and rub it to a smooth paste, heat the mixture on a water-bath, and gradually add ammonia water until the salt is dissolved and the liquid is neutral or has only a faintly alkaline reaction. Then filter the solution, evaporate it on a water-bath to a syrupy consistence, and spread it upon plates of glass, so that, when dry, the salt may be obtained in scales. Keep the product in amber-colored, well-stoppered bottles, protected from light.

Chemical Explanation.—As mentioned in preceding process, bismuth citrate is insoluble in water, but it does dissolve in ammonia water, forming with it a loose chemical combination, which, when scaled, is soluble in water.

Calculations.—As the combination between the bismuth citrate and the ammonia is very indefinite, no attempt will be made to work out molecular proportions.

Remarks on Process.—*Rub bismuth citrate to smooth paste,* by placing in pint evaporating dish and triturating with water, gradually added, with the pestle.

Gradually add ammonia water until the salt is dissolved—10 mils usually suffices. An excess works no harm, since it dissipates during the evaporation. While not specified by the pharmacopœia, the addition of a few drops of ammonia water, from time to time during the evaporation, aids in getting a completely soluble product.

Evaporate and scale as in making ferric citrate, only spread the thin syrup *very thinly* on glass. If spread even as thin as ferric citrate, opaque scales are formed. If very thin, beautiful pearly scales result.

MAKE LEAD PLASTER (U.S.P. VIII)

Recipe.—	**Soap,** dried, and in coarse powder	10 Gm.
	Lead acetate	6 Gm.
	Water, a sufficient quantity.	

Dissolve the soap in 35 mils of hot water and strain the solution. Dissolve the lead acetate in 25 mils of hot water, and at once filter the solution into the warm soap solution, stirring constantly.

When the precipitate has subsided, decant the liquid, and wash the precipitate thoroughly with hot water. Transfer the mass to a warm slab, kneading it thoroughly to free it from water. Finally, roll the plaster into cylindric forms and wrap them in paraffined paper.

Chemical Explanation.—This type of lead plaster, prescribed by the last pharmacopœia is typical of the line of solid oleates (or, more correctly, oleo-palmitates) such as those of zinc and of copper. These are made by mixing a solution of castile soap (sodium oleate and sodium palmitate) with a solution of salt of the metal desired. In the case of lead plaster (U.S.P. VIII.) the reaction runs:

Sodium oleate plus *lead acetate* give *lead oleate* plus *sodium acetate.*

Write out the equation showing this reaction.

As neither Castile soap nor lead plaster are definite chemicals, no attempt will be made to calculate quantities by molecular weights.

Remarks on Process.—*Dissolve the soap* in pint flask, and strain into pint evaporating dish.

Dissolve the lead acetate in another pint flask (or same one, carefully washed), and filter into soap solution in dish.

Knead the mass on pill-tile.

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